

**A REVIEW OF THE EXISTING AND POTENTIAL ROLE OF**

**LEGUMES IN FARMING SYSTEMS**

**OF THE NEAR EAST**

**AND NORTH AFRICAN REGION**

**A REPORT TO I C A R D A**

**BY**

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A REVIEW OF THE EXISTING AND POTENTIAL ROLE OF LEGUMES IN  
FARMING SYSTEMS OF THE NEAR EAST AND NORTH AFRICAN REGION

A REPORT TO THE  
INTERNATIONAL CENTRE FOR AGRICULTURAL RESEARCH IN THE DRY AREAS  
(ICARDA)

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March 1978

## PREFACE

In the Region comprising the Near East and North Africa there has been increasing concern at the deficit in food production which has occurred despite the national agricultural development programmes and the aid from bilateral and multilateral agencies. Not only has there been a deficit in the production of human food but also a rapidly-increasing deficit in livestock feed in most countries of the Region. These deficits are the consequence of a rapid increase in both human population and livestock numbers in the past 30 years.

Most Governments of the Region have recognized these agricultural problems and taken steps to achieve national self-sufficiency in cereal production. This has involved *inter alia* the improvement of cereal research programmes. These research and development aspirations in the Region have been greatly assisted by the various projects of UNDP/FAO (especially the Regional Project on the Improvement and Production of Field Food Crops), CIMMYT, The Rockefeller Foundation, The Ford Foundation, USAID, DANIDA, NORAD, SIDA, the French CCE and others. Though there have been some spectacular improvements in cereal production in the Region some of these advances have been at the expense of the pasture-livestock sector which in most countries has been grossly neglected.

Although huge areas of arid and semi-arid rangelands have been devastated, there is great potential for increasing livestock feed production through widespread use of pasture and forage-crop legumes on the fallow areas in the traditional rainfed and irrigated cropping zones; there is also a large potential to improve pasture production in the humid zones throughout the Region. Not only is there substantial potential to increase livestock production based on leguminous pastures and forage crops but also cereal production as a consequence of nitrogen fixation by properly nodulated legumes. Implicit in any programmes to grow this additional livestock feed is the need for much better crop-livestock integration in the Region.

The report that follows represents a broad appraisal of the existing crop and livestock situation in the Region and the opportunities for increasing both cereal and livestock production. I have avoided reporting on well-known, and relatively static physiographic, climatic and edaphic features of the Region and have concentrated on those aspects related to the dynamic crop and pasture-livestock scene and the potential for change. However, the views expressed and conclusions are my own and in no way commit ICARDA to any specific course of action now or in the future. Five visits to the Region during the period 1973-1977 involving extensive road travel and field inspections have given me a clear picture of the existing and potential land use and some of the related agronomic, economic and social constraints.

It was soon obvious to me that there were clear ecological analogies between North Africa, and to a lesser extent the Near East, and southern Australia and that South Australia had a great deal to offer in the science and technology of land clearing, tillage practice, pasture improvement (especially the potential use of self-regenerating pasture legumes in a ley-farming system) and general techniques related to cereal and livestock production and integration of these enterprises, as well as being an ecologically-relevant place for postgraduate students from the Region.

My visits to the Region have been in the following capacities:

- (i) Member of the TAC Research Review Mission to the Near East and North Africa in March-April 1973, which recommended the need for a new international centre in the Region. This Centre is now a reality with the founding of ICARDA (Skilbeck *et al.* 1973; Pelton and Brough 1977).

- (ii) Consultant to CIMMYT in Algeria during the period March-April 1974 on the potential role of legumes in crop and livestock production (Carter 1974a,b; 1975a);
- (iii) Invited participant assisting with the First Workshop of National Task Force Leaders involved in the FAO/UNDP Regional Project on the Improvement and Production of Field Food Crops at Lahore-Peshawar-Karachi, Pakistan, March 1975 (Carter 1975b).
- (iv) Member of World Bank Research Review Mission to Western Sudan during the period February-March 1977.
- (v) Consultant to ICARDA on the existing and potential role of legumes in farming systems of the Near East and North African Region as follows:

Period April-May, 1977: Algeria, Tunisia, Libya, Jordan, Syria and Iraq.

Period June-July, 1977: Turkey, Iran and Afghanistan.

The background to and terms of reference for this ICARDA consultancy, together with the itinerary are included in Appendix C of this report.

My thanks are due to the many people in the Near East and North Africa who helped me to fulfil my mission and to make my stay both useful and enjoyable. The list of organizations and people contacted during this consultancy is included as Appendix B of this report. I am most grateful to those persons listed, and any who may have been inadvertently omitted, who gave of their time and information.

Finally, it is a pleasure to record my thanks to Dr. H.S. Darling, Director-General of ICARDA for arranging ICARDA finance to enable me to undertake these further studies on the pasture-livestock sector in the Near East and North Africa.

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23/3/78

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(1) All tables refer to the Near East and North African Region.		
(2) Appendix A contains a further eight tables specifically referred to in the text as Appendix tables.		

DEFINITIONS OF PASTURE, RANGELAND, FORAGE CROP AND FODDER

While there is no universal agreement on terminology, the following definitions apply to the terms, listed below, that are used throughout the report.

- (i) Pasture: A dynamic community of plants subjected to the various influences of the grazing animal (treading, defoliation, recycling of nutrients, dispersal of seeds). The pasture may be a mono-specific sward or a complex community of many genera and species. The general term embraces the full range of environments, e.g. from steppe rangelands to mountain meadows.
- (ii) Native Pasture: Pasture dominated by indigenous perennial species (but often with associated annual species), including both climax and disclimax pastures.
- (iii) Natural Pasture: Volunteer (or spontaneous) pasture resulting from the activities of man and his grazing animals but without artificial sowing. Natural pasture is commonly characterized by dominance of annual species, frequently naturalized species introduced from elsewhere. The volunteer species may be the same species as are frequently sown, e.g. *Medicago truncatula* and *Trifolium subterraneum* which have spread naturally in many areas of southern Australia.
- (iv) Sown Pasture: Annual and/or perennial species sown (usually with fertilizer) to increase the livestock carrying capacity of the area. The process is also referred to as pasture improvement when one or more species is introduced either on cultivated soil or into native or natural pasture.
- (v) Permanent Pasture: Pasture developed by sowing perennial species with or without associate annuals and usually in higher-rainfall areas. The perennial species confer stability of botanical composition but do not necessarily increase pasture productivity.
- (vi) Rangeland: Arid-zone pasture (including steppe) dominated by perennial species and unsuited to cropping because of aridity or steep and shallow soils: generally not capable of improvement without exclusion of grazing animals, and furrowing, pitting, etc., to collect seed and water. Although ecologically possible to improve by oversowing appropriate species this is generally economically impracticable. Conservative stocking is obligatory.
- (vii) Forage Crop: Green crop sown to supplement normal pasture and frequently cut and carted to feed livestock. These forage crops may be sown annual species, e.g. vetch, with or without associate cereal, for winter feed; turnips, sudan grass, etc., for summer feed; or perennial species like alfalfa or sainfoin.
- (viii) Fodder: Any dried and stored or conserved feedstuff e.g., cereal hay, straw, cereal grain, pasture hay, forage hay, swedes, fodder beet, etc.

LIST OF SCIENTIFIC AND COMMON NAMES OF LEGUMES

<u>Scientific Name</u>	<u>Common Name</u>
<i>Cicer arietinum</i>	Chickpea
<i>Lathyrus sativus</i>	Chickling vetch
<i>Lens culinaris</i>	Lentil
<i>Medicago littoralis</i>	Strand medic
<i>Medicago rugosa</i>	Gama medic
<i>Medicago sativa</i>	Alfalfa (= lucerne)
<i>Medicago scutellata</i>	Snail medic
<i>Medicago tornata</i>	Disc medic
<i>Medicago truncatula</i>	Barrel medic
<i>Onobrychis sativa</i>	Sainfoin
<i>Pisum arvense</i>	Field pea
<i>Pisum sativum</i>	Garden pea
<i>Trifolium alexandrinum</i>	Berseem clover
<i>Trifolium fragiferum</i>	Strawberry clover
<i>Trifolium resupinatum</i>	Persian clover
<i>Trifolium subterraneum</i>	Subterranean clover
<i>Trigonella foenum-graecum</i>	Fenugreek
<i>Vicia amphicarpa</i>	Subterranean vetch
<i>Vicia dasycarpa</i>	Woolly-pod vetch
<i>Vicia ervilia</i>	Bitter vetch
<i>Vicia faba</i>	Broad bean
<i>Vicia monantha</i>	Bard vetch
<i>Vicia narbonensis</i>	Narbonne vetch
<i>Vicia pannonica</i>	Hungarian vetch
<i>Vicia sativa</i>	Common vetch
<i>Vicia villosa</i>	Hairy vetch

Note: The above list does not include all legumes referred to in this report, only those referred to by common name.

## I. BACKGROUND AND PERSPECTIVE

### 1. The Environments of the Near East - North African Region

The physical environments and agriculture of much of the Near East and North African Region<sup>+</sup> have been described by Nuttonson (1958, 1961a,b) and Clawson, Landsberg and Alexander (1971) while valuable studies on the ecology and land use include those by UNESCO-FAO (1963), LeHouerou (1970), FAO (1972) and Rafiq (1976).

The climate of the Region has been reviewed by Brichambaut and Wallen (1963) who recognized twelve agro-climatic sub-zones, and by Landsberg *et al.* (1963). The Region is characterised by winter rainfall (or snow) and hot dry summers when evapo-transpiration exceeds precipitation for several months. i.e. the typical Mediterranean-type and related semi-arid steppe climates which also occur in southern Australia, California, Chile and in South Africa. Nuttonson (1958) and Carter (1974b, 1975a, 1975b) have emphasized the close climatic and edaphic analogies between parts of southern Australia and some countries of the Near East and North African Region. Further supporting evidence is given by Stephens (1957, 1962), Leeper (1970), and Gentilli (1971).

Although the amount and distribution of precipitation determine the period during which rainfed crops and pastures can grow, winter and spring temperatures set limits to production. The main factors affecting temperatures are altitude, aspect and distance from the sea, and the interaction of these factors evolve the agro-climatic sub-zones within the Mediterranean climate and the related semi-arid 'Continental' climates of the high plateaus of Afghanistan, Northern Iran, Central Turkey, East Morocco, and Algeria (and of course, Central Spain and other high-altitude areas of southern Europe. Important agro-climatic sub-zones of the Region as classified by Troll and Paffen (Landsberg *et al.* 1963) are as follows:

- IV 1 Dry-summer Mediterranean climates with humid winters (mostly more than 5 humid months): sub-tropical hard-leaved and coniferous wood (represented by a relatively narrow coastal strip).
- IV 2 Dry-summer steppe climates with humid winters (mostly less than 5 humid months): sub-tropical grass and shrub-steppe.
- IV 5 Semi-desert and desert climates without hard winters, but frequent transient or night frosts (generally less than 2 humid months): sub-tropical semi-deserts and deserts.
- III 7a Dry and warm summer climates with a mild to moderately cold but slightly humid winter: thermophile dry wood and wooded steppe.
- III 10 Steppe climates with cold winters, arid summers and less than 6 months of humidity: short grass, or dwarf shrub, or thorn steppe.

The broad agricultural and socio-economic problems relating to the deficit in food production in the Region were summarized in the report of the Research Review Mission to the Near East and North Africa (Skilbeck *et al.* 1973).

Figure 1 shows the extent of the Region together with the mid-1977 populations of most countries. Current land use and population data for all countries of the Region are summarized in Table 1.

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<sup>+</sup>Throughout this report the term 'Region' will embrace both the Near East and North African countries: however, there are no universally-accepted definitions of the extent of these two geographic areas - much of which is referred to as the Middle East.

FIGURE 1

The Near East and North African countries shown on the map, together with Gaza (0.4), Israel (3.6) and the United Arab Emirates (0.2), had a mid-1977 population of 328 million with an annual rate of population growth of about 2.8 percent.

Sources: The Population Data Sheet 1977 of the Population Reference Bureau, Inc. Washington D.C., U.S.A. was used for all countries except Saudi Arabia, Sudan and Yemen Arab Republic. Because of discrepancies in the estimates of population for these three countries, the populations shown on the map (and in Table 1) were extrapolated from earlier data in the FAO Production Yearbook, Vol. 29, 1975.

# NORTH AFRICA AND THE NEAR EAST ( Population 1977, 328 million )

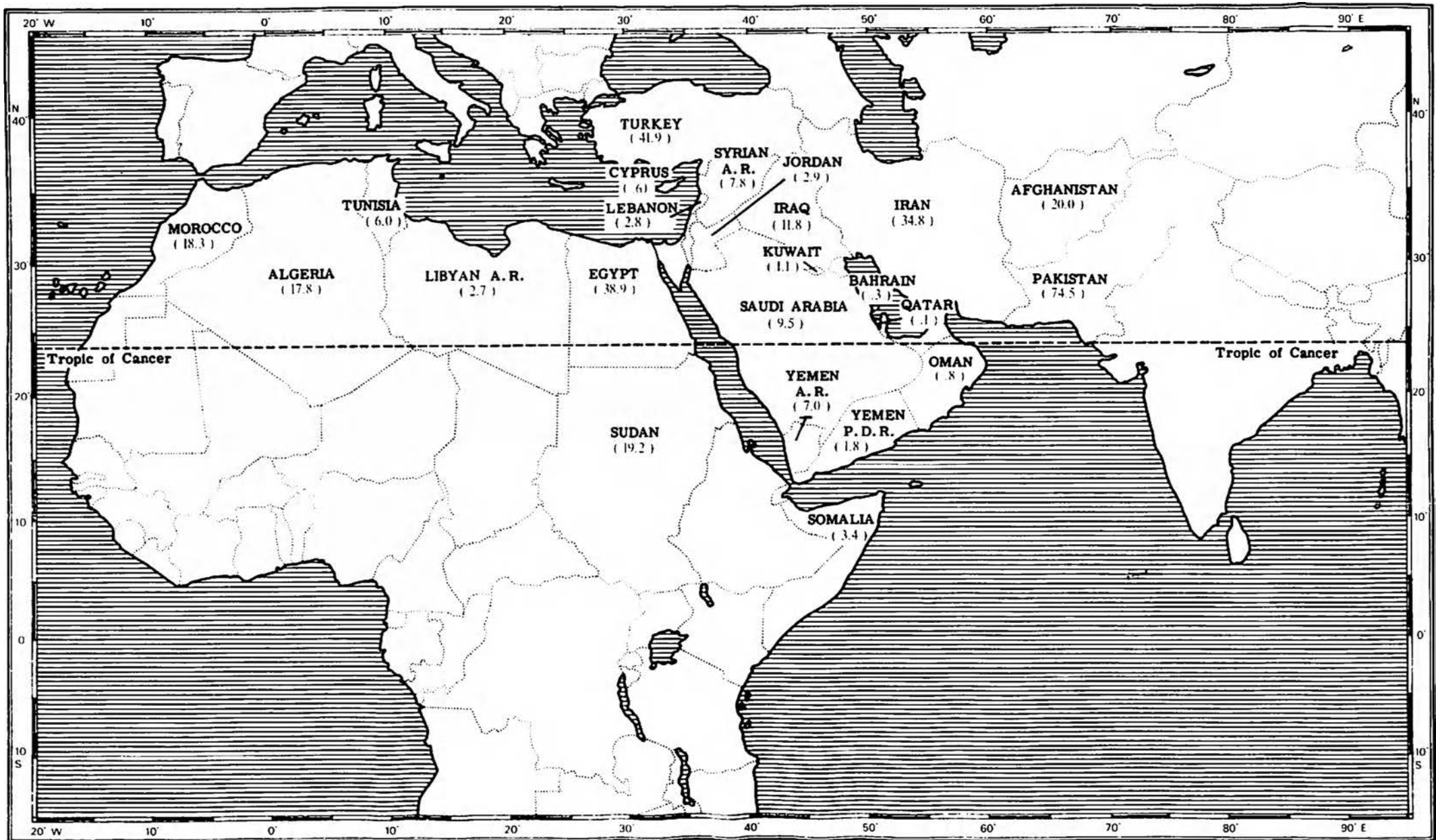


TABLE 1

## SOME STATISTICS OF THE NEAR EAST AND NORTH AFRICAN REGION

Countries	Population	Total Area	Total Arable Land and Permanent Crop Land		Irrigated Arable and Permanent Crop Land		Permanent Meadows & Pastures <sup>+</sup>	
	(Millions)	(1000 ha)	(1000 ha)	Percentage of Total	(1000 ha)	Percentage of Arable	(1000 ha)	Percentage of Total
Afghanistan	20.0	64,750	8,467	13.1	2,420	28.6	5,960	9.2
Algeria	17.8	238,174	7,000	2.9	300	4.3	38,452	16.1
Bahrain	0.3	62	2	3.2	1	50.0	4	6.5
Cyprus	0.6	925	432	46.7	94	21.8	93	10.1
Egypt	38.9	100,145	2,855	2.9	2,855	100.0	-	-
Iran	34.8	164,800	16,280	9.9	5,350	32.9	11,000	6.7
Iraq	11.8	43,492	9,380 <sup>x</sup>	21.6	4,100	43.7	4,000	9.2
Israel	3.6	2,070	430	20.8	177	41.2	818	39.5
Jordan	2.9	9,774	1,360	13.9	60	4.4	100	1.0
Kuwait	1.1	1,782	1	0.1	1	100.0	134	7.5
Lebanon	2.8	1,040	348	33.5	85	24.4	10	1.0
Libyan Arab Republic	2.7	175,954	2,544	1.4	130	5.1	6,850	3.9
Morocco	18.3	44,655	7,630	17.1	850	11.1	12,500	28.0
Oman	0.8	21,246	36	0.2	-	-	1,000	4.7
Pakistan	74.5	80,394	19,450	24.2	14,100	72.5	5,000	6.2
Qatar	0.1	1,100	2	0.2	-	-	50	4.5
Saudi Arabia	9.5	214,969	775	0.4	185	23.9	85,000	39.5
Somalia	3.4	63,766	1,050	1.6	162	15.4	28,850	45.2
Sudan, The	19.2	250,581	7,195	2.9	870	12.1	24,000	9.6
Syrian Arab Republic	7.8	18,518	6,027	32.5	578	9.6	6,393	34.5
Tunisia	6.0	16,361	4,360	26.6	90	2.1	3,250	19.9
Turkey	41.9	78,058	27,895	35.7	1,970	7.1	27,600	35.4
United Arab Emirates	0.2	8,360	13	0.2	5	38.5	200	2.4
Yemen, Arab Republic	7.0	19,500	1,240	6.4	100	8.1	7,000	35.9
Yemen, Peoples Dem. Rep.	1.8	28,768	334	1.2	5	1.5	9,065	31.5
N.E. & N.A. Region	327.8	1,649,244	125,106	7.6	34,311	27.4	277,329	16.8

Sources: Population data are the estimates for mid-1977 from the Population Reference Bureau, Washington D.C., U.S.A.  
(See comments on Figure 1).

Information on land use from FAO Production Yearbook: Vol.29, 1975.

+Obviously some of the rangeland areas have not been included in the statistics on permanent meadows and pastures.

<sup>x</sup>Derived figure used because of an apparent error in the 1975 Yearbook.

## 2. The Agriculture of the Region

Of the twenty five countries comprising the Near East-North African Region (Table 1), only nine of the important agricultural countries of the Region will be considered in detail and Israel is excluded from comments and discussion on the Region. In recent years oil and gas revenues have provided a unique opportunity for economic and social development in the Region. Yet, although there is a dominance of employment in agriculture (Table 2), investment in the agricultural sector has been relatively low (Table 3).

TABLE 2

AGRICULTURAL POPULATION AND POPULATION ECONOMICALLY ACTIVE IN AGRICULTURE  
DURING THE PERIOD 1960-1976

(Thousands)

Country	Total Population	Agricultural Population	Economically Active Population		
			Total	Total in Agriculture	Percent in Agriculture
Afghanistan					
1960	13736	11717	4952	4224	85.3
1970	16978	13866	5952	4861	81.7
1976	19796	15725	6728	5344	79.4
Algeria					
1960	10800	7215	2880	1924	66.8
1970	14330	8702	3254	1976	60.7
1976	17346	9283	3891	2102	54.0
Iran					
1960	21554	11617	6427	3464	53.9
1970	28359	13048	8224	3784	46.0
1976	33957	13754	9582	3976	41.5
Iraq					
1960	6847	3636	1817	965	53.1
1970	9356	4360	2410	1123	46.6
1976	11453	4898	2868	1227	42.8
Jordan					
1960	1695	745	432	190	44.0
1970	2280	769	566	191	33.7
1976	2779	804	670	194	28.9
Libyan A.R.					
1960	1349	718	370	197	53.2
1970	1938	622	517	166	32.1
1976	2325	495	599	128	21.3
Syrian A.R.					
1960	4561	2472	1277	692	54.2
1970	6247	3193	1657	847	51.1
1976	7490	3663	1941	949	48.9
Tunisia					
1960	4221	2379	1139	642	56.4
1970	5137	2562	1217	607	49.9
1976	5893	2599	1414	624	44.1
Turkey					
1960	27509	21585	13783	10815	78.5
1970	35232	23865	15590	10560	67.7
1976	40908	24500	17432	10440	59.9

Source: FAO Production Yearbook Vol.29, 1975 and Vol.30, 1976.

TABLE 3

## MAIN FEATURES OF CURRENT DEVELOPMENT PLANS IN NINE COUNTRIES OF THE REGION

Country	Growth Rate (Percent/year)		Duration  of  Plan	Planned Growth Rate (Percent/year)			Share of Agriculture (Percent)	
	Popu- lation	Food Demand		GDP	Agricultural Production		Total Invest- ment	Public Invest- ment
					Total Cereals			
Afghanistan	2.6	3.3	1973-77	5.0	4.2	4.6	35.0	39.0
Algeria	3.1	3.4	1974-77	11.2	4.2	4.7	n a	10.9
Iran	3.0	4.7	1973-78	25.9	7.0	9.0	11.4	12.8
Iraq	n a	n a	1970-74	7.1	7.0	n a	19.7	24.5
Jordan	3.2	2.6	1976-80	11.5	7.0	7.5	18.0	30.0
Libyan A.R.	4.1	4.8	1976-80	10.7	15.8	9.0	12.0	12.0
Syrian A.R.	n a	n a	1971-75	8.2	5.1	n a	31.5	39.0
Tunisia	2.3	7.1	1977-81	7.5	3.6	3.5	15.8	26.2
Turkey	2.5	3.5	1973-77	7.9	4.6	3.4	11.7	52.7

Note: The agricultural sector includes animal production, fisheries, forestry, irrigation, land reclamation, community development and agricultural extension, but does not include major development projects concerned with irrigation and drainage, flood control and dams and dykes which are part of these projects. n a = not available.

Sources: The State of Food and Agriculture 1976. FAO (1977a).  
Near East Statistical Directory 1975 (Iraq and Syria only).

As a consequence of national agricultural development programmes and despite considerable aid from both bilateral and multilateral agencies, there is a continuing, or increasing, deficit in food production in some countries of the Region. This food deficit has been of major concern to United Nations Agencies and others for some years. Even with a reasonably high growth rate in food production, the projected Regional deficit by 1985 for major food commodities could amount to about 5 million metric tons (5 M t)<sup>+</sup> of wheat, 2.5 M t of sugar, 0.5 M t of vegetable oils and 0.7 M t of meat (FAO 1977a).

Although total food production in recent years has generally increased - through greater inputs rather than increased area except in Iran where both have increased - food production has fallen behind population increase in several countries of the Region (Tables 4,5,6). Despite the general increase in per caput food production in the Region, food imports have risen so fast that the Region has become the largest per caput food importer of the developing regions of the world. In part, this reflects the ability to pay for imports. Certainly, there are no serious problems of human undernutrition in the nine countries considered (Tables 7,8) though costs of food and other essentials are a serious problem to low-income families (Table 9).

The reasons for the human population explosion are well known and need no elaboration. Less well known is the fact that at the same time and for similar reasons (better hygiene, disease prevention and control and better nutrition) there has also been a substantial increase in livestock numbers (Tables 10,11 and Appendix A, Table 1) despite a diminishing area of grazing land of declining productivity. The problems of the pasture-livestock sector in relation to overall degradation of grazing resources will be further discussed in later sections of this report. Unlike the human population, many livestock are underfed.

<sup>+</sup> Hereafter, M = million and t = metric ton (1000 kg).

TABLE 4

## TRENDS IN PRODUCTION OF CEREALS AND PULSES IN NINE COUNTRIES OF THE NEAR EAST - NORTH AFRICAN REGION

	1961-65		1973		1974		1975		Change 1973-75/1961-65	
	Area <sup>+</sup> (1000ha)	Prod. <sup>++</sup> (1000t)	Area (1000ha)	Prod. (1000t)	Area (1000ha)	Prod. (1000t)	Area (1000ha)	Prod. (1000t)	Area (%)	Prod. (%)
Afghanistan										
Total Cereals	3404	3661	3258	4310	3324	4462	3324	4573	-3.0	+21.5
Total Pulses	28	45	33	55	34	55	34	55	+20.2	+22.2
Algeria										
Total Cereals	2838	1771	3233	1596	2674	1480	3030	2680	+5.0	+8.3
Total Pulses	66	35	88	42	86	43	89	46	+32.8	+24.8
Iran										
Total Cereals	4912	4568	6842	6910	6898	6923	7583	8399	+44.7	+62.2
Total Pulses	198	166	156	156	151	145	172	179	-19.4	-3.6
Iraq										
Total Cereals	2230	1854	1703	1603	2203	1969	1948	1511	-12.5	-8.6
Total Pulses	42	35	47	35	48	37	48	38	+13.5	+4.8
Jordan										
Total Cereals	346	251	133	56	281	285	135	76	-47.1	-44.6
Total Pulses	48	30	40	9	42	48	42	42	-13.9	+10.0
Libyan A.R.										
Total Cereals	503	126	438	275	419	165	418	273	-15.5	+88.6
Total Pulses	6	2	7	7	7	6	7	7	+16.7	+233.3
Syrian A.R.										
Total Cereals	2203	1799	2426	725	2278	2325	2753	2210	+12.8	-2.5
Total Pulses	194	150	241	81	255	210	233	161	+25.3	+0.4
Tunisia										
Total Cereals	1601	681	1595	920	1515	948	1503	1268	-4.0	+53.5
Total Pulses	55	29	83	80	87	77	92	81	+58.8	+173.6
Turkey										
Total Cereals	12947	14831	13148	15699	13179	17067	13370	21784	+2.2	+22.6
Total Pulses	570	592	616	589	604	663	619	678	+7.5	+8.7

<sup>+</sup> Area harvested in thousands of hectares.      <sup>++</sup> Production in thousands of metric tons.

Cereals include: wheat, rice, barley, maize, rye, oats, millet, sorghum, and others.

Pulses include: dry beans, broad beans, dry peas, chick peas, cow peas, pigeon peas, lentils, vetches, lupins and others.

Sources: FAO Production Yearbook Vol.29, 1975 and Vol.30, 1976.

TABLE 5

TOTAL CROP AREA, NUMBER OF AGRICULTURAL TRACTORS AND FERTILIZER USE IN NINE COUNTRIES OF THE NEAR EAST - NORTH AGRICAN REGION

	Total Crop Area (1000 ha)	Agricultural Tractors	Fertilizer Consumption <sup>+</sup> (Metric tons)		
			N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
Afghanistan					
1961-65	3744	194	1000	100	-
1975	3789	700	21392	9582	25
Change	+1.2%	+261%	+2039%	+9482%	∞%
Algeria					
1961-65	3338	27620	14269	20907	14534
1975	3494	51000	76600	76275	26412
Change	+4.7%	+84.6%	+437%	+265%	+81.7%
Iran					
1961-65	5959	11300	12033	10260	1990
1975	8845	29000	175221	123268	2149
Change	+48.4%	+157%	+1356%	+1101%	+8.0%
Iraq					
1961-65	2460	5000	1792	540	168
1975	2279	20222	21864	6760	1171
Change	-7.4%	+304%	+1120%	+1152%	+597%
Jordan					
1961-65	479	1335	1029	787	1305
1975	207	3400	1775	1825	758
Change	-56.8%	+155%	+72.5%	+132%	-41.9%
Libyan A.R.					
1961-65	534	2834	1851	1796	456
1975	492	4250	9775	11025	1350
Change	-7.9%	+50.0%	+428%	+514%	+196%
Syrian A.R.					
1961-65	2901	6310	12512	4730	756
1975	3519	15303	36189	14342	1640
Change	+21.3%	+143%	+189%	+203%	+117%
Tunisia					
1961-65	1801	11795	4940	12067	2764
1975	1745	29000	18837	14676	3875
Change	-3.1%	+146%	+281%	+21.6%	+40.2%
Turkey					
1961-65	16208	48043	53700	44481	2508
1975	17342	242456	383680	279470	16975
Change	+7.0%	+405%	+615%	+528%	+577%

<sup>+</sup> Mean values for four years 1972-73 to 1975-76 have been used instead of the 1975 value which, in several cases, reflected distorted prices.

Sources: FAO Production Yearbook Vol.29, 1975 and Vol.30, 1976.  
FAO Annual Fertilizer Review 1976.

TABLE 6

INDICES OF POPULATION, AGRICULTURAL PRODUCTION, AND AGRICULTURAL PRODUCTION PER CAPUT IN NINE COUNTRIES OF THE NEAR EAST - NORTH AFRICAN REGION

(1961-65 = 100)

	Population		Agriculture		Agric.Prod/Caput	
	1975	1976	1975	1976	1975	1976
Afghanistan	133	137	126	131	95	96
Algeria	148	153	125	135	85	88
Iran	141	145	161	171	114	118
Iraq	147	153	115	136	78	89
Jordan	147	152	53	61	36	40
Libyan A.R.	150	154	172	179	115	116
Syrian A.R.	145	149	135	145	93	97
Tunisia	129	133	181	179	140	135
Turkey	134	138	160	168	119	122

Source: FAO Production Yearbook Vol.29, 1975 and Vol.30, 1976.

TABLE 7

PER CAPUT DIETARY ENERGY SUPPLIES IN RELATION TO NUTRITIONAL REQUIREMENTS

Country	Percent Requirements					Requirements Kilocalories per caput per day
	Average 1969-71	Average 1972-74	1972	1973	1974	
Afghanistan	80	82	80	83	83	2440
Algeria	78	83	84	86	88	2400
Iran	90	96	95	97	98	2410
Iraq	95	99	98	98	101	2410
Jordan	94	90	93	87	90	2460
Libyan A.R.	108	114	111	115	117	2360
Syrian A.R.	99	102	101	101	104	2480
Tunisia	93	99	99	98	102	2390
Turkey	112	112	112	112	113	2520

Source: The State of Food and Agriculture 1976. FAO (1977a).

TABLE 8

## MEAN PER CAPUT DIETARY ENERGY AND PROTEIN SUPPLIES

Country	Source	Calories per caput per day		Protein per caput per day	
		1961-65	1974	1961-65	1974
Afghanistan	Total	2108	2022	65.2	62.1
	Vegetable	1971	1900	57.4	55.2
	Animal	137	122	7.8	6.9
Algeria	Total	1897	2121	50.7	57.1
	Vegetable	1710	1896	40.5	45.4
	Animal	187	225	10.2	11.7
Iran	Total	1890	2367	45.9	55.7
	Vegetable	1692	2165	35.8	43.6
	Animal	198	202	10.1	12.1
Iraq	Total	2028	2433	52.4	60.4
	Vegetable	1795	2169	37.9	44.1
	Animal	233	264	14.5	16.3
Jordan	Total	2214	2213	53.5	52.9
	Vegetable	2062	2028	43.9	40.8
	Animal	152	185	9.6	12.1
Libyan A.R.	Total	1854	2765	47.6	70.0
	Vegetable	1688	2416	37.4	49.2
	Animal	166	349	10.2	20.8
Syrian A.R.	Total	2416	2580	61.5	66.0
	Vegetable	2151	2301	47.3	51.3
	Animal	265	279	14.2	14.7
Tunisia	Total	1985	2440	51.5	67.4
	Vegetable	1832	2213	41.6	52.2
	Animal	153	227	9.9	15.2
Turkey	Total	2771	2848	75.3	75.8
	Vegetable	2464	2549	57.0	56.7
	Animal	307	299	18.3	19.1

Source: FAO Production Yearbook Vol.30, 1976. FAO (1976b).

TABLE 9

ANNUAL CHANGES IN CONSUMER PRICES IN SEVEN COUNTRIES  
(Percent per year)

Country	All Items			Food Items		
	1965-70	1972-73	1974-75	1965-70	1972-73	1974-75
Iran	1.4	9.8	13.0	0.9	6.8	12.2
Iraq	3.5	4.9	9.6	3.1	4.9	13.7
Jordan	2.8	10.5	21.0	5.1	18.9	22.6
Libyan A.R.	6.1	7.7	8.7	8.3	-9.1	8.2
Syrian A.R.	4.2	20.0	16.1	4.7	22.1	18.9
Tunisia	2.9	4.4	9.5	3.1	6.6	9.5
Turkey	7.1	16.0	20.1	8.7	20.0	30.0

Source: The State of Food and Agriculture 1976. FAO(1977a).

TABLE 10

COMPARATIVE CHANGES IN POPULATION AND LIVESTOCK NUMBERS OVER A THIRTEEN-YEAR PERIOD 1963 TO 1976 IN NINE COUNTRIES OF THE NEAR EAST-NORTH AFRICAN REGION

	People (1000)	Cattle <sup>+</sup> (1000)	Sheep <sup>+</sup> (1000)	Goats <sup>+</sup> (1000)	Camels <sup>+</sup> (1000)
<b>Afghanistan</b>					
1963	14474	3230	17940	3757	318
1976	19796	3676	18000	2350	290
Change	+36.8%	+13.8%	+ 0.3%	-37.5%	-8.8%
<b>Algeria</b>					
1963	11383	810	6180	1950	165
1976	17346	1281	8886	2400	157
Change	+52.4%	+58.2%	+43.8%	+23.1%	-4.8%
<b>Iran</b>					
1963	23261	5060	30410	13006	234
1976	33957	6650	35300	14300	60
Change	+46.0%	+31.4%	+16.1%	+10.0%	-74.4%
<b>Iraq</b>					
1963	7657	1531	10138	2209	200
1976	11453	2081	8400	2584	330
Change	+49.6%	+35.9%	-17.1%	+17.0%	+65.0%
<b>Jordan</b>					
1963	1858	61	752	592	17
1976	2779	35	818	474	18
Change	+49.6%	-42.6%	+8.8%	-19.9%	+5.9%
<b>Libyan A.R.</b>					
1963	1549	106	1378	1281	266
1976	2325	123	3360	1125	120
Change	+50.1%	+16.0%	+143.8%	-12.2%	-54.9%
<b>Syrian A.R.</b>					
1963	4958	454	4035	668	11
1976	7490	555	6200	750	6
Change	+51.1%	+22.2%	+53.7%	+12.3%	-45.5%
<b>Tunisia</b>					
1963	4113	562	2804	525	158
1976	5893	880	3526	900	195
Change	+43.3%	+56.6%	+25.7%	+71.4%	+23.4%
<b>Turkey</b>					
1963	29628	12621	32863	22665	54
1976	40908	13751	41367	18763	18
Change	+38.1%	+ 9.0%	+25.9%	-17.2%	-66.7%

<sup>+</sup>The livestock numbers shown for 1963 are mean figures for the period 1961-65.  
Source: FAO Production Yearbooks Vol.26, 1972 and Vol.30, 1976.

Note: The Iraqi sheep numbers shown above may be queried as the mean figure for the three-year period 1973-75 was 15,610 according to Yearbook 29, 1975.

TABLE 11

COMPARATIVE CHANGES IN POPULATION AND LIVESTOCK NUMBERS OVER THE THIRTEEN-YEAR PERIOD 1963-1976 IN THREE SUB-REGIONS OF THE NEAR EAST - NORTH AFRICAN REGION

	People (1000)	Cattle <sup>+</sup> (1000)	Sheep <sup>+</sup> (1000)	Goats <sup>+</sup> (1000)	Camels <sup>+</sup> (1000)
Algeria, Tunisia and Libya					
1963	17045	1478	10362	3756	589
1976	25564	2284	15772	4425	472
Change	+50.0%	+54.5%	+52.2%	+17.8%	-19.9%
Jordan, Syria and Iraq					
1963	14473	2046	14925	3469	228
1976	21722	2671	15418	3808	354
Change	+50.1%	+30.5%	+ 3.3%	+ 9.8%	+55.3%
Turkey, Iran and Afghanistan					
1963	67363	20911	81213	39428	606
1976	94661	24077	94667	35413	368
Change	+40.5%	+15.1%	+16.6%	-10.2%	-39.3%
Total Nine Countries					
1963	98881	24435	106500	46653	1423
1976	141947	29032	125857	43646	1194
Change	+43.6%	+18.8%	+18.2%	- 6.4%	-16.1%

<sup>+</sup>The livestock numbers shown for 1963 are mean figures for the period 1961-65.  
Sources: FAO Production Yearbooks Vol.26, 1972 and Vol.30, 1976.

The foregoing tables provide the background for later comments on some of the within-country problems of agricultural production. Three common features of the Region arise from Government policies aimed at attaining national self-sufficiency in food production and earning export income. These are as follows:

- (i) the very considerable investment in irrigated agriculture;
- (ii) the inadequate attention to and relative neglect of the necessary financial incentives and support for rainfed agriculture and particularly the pasture/livestock sector in most countries; and
- (iii) the development of mechanized farming with horizontal expansion of crop area onto marginal rainfed lands formerly used for grazing. Inevitably this has led to conflict between the cereal growers and the livestock owners and had some disastrous consequences in terms of destruction of grazing areas, increased wind and water erosion and desert encroachment.

The land use and population data shown in Table 1 are very significant in several respects. First, the percentage of land suited to arable agriculture is low (7.6%) with little scope for much horizontal expansion. Apart from some apparent potential for expansion of cropping areas in Afghanistan and Iran and potential for considerable expansion of cropping on clay soils in the Sudan, there will be need for an overall retraction of cropping from marginal rainfall areas in most countries of the Region. The second point concerns the fact that although 27.4% of the arable land is currently irrigated, there is little scope for greatly expanding this area without very heavy expenditure in irrigation and drainage works. The third point concerns the very high percentage of rangelands in the Region. The rangeland data shown in Table 1 is quite inadequate but, according to calculations, rangelands occupy 85% of the Region.

The Near East and North Africa are not alone in these matters. Australia, with a total area of 768.23 M ha, is currently using only 46 M ha (6.0%) for crops and sown pastures, of which only 1.7 M ha (3.7% of arable) are irrigated, while some 400 M ha of the total area of c.570 M ha of arid and semi-arid rangeland (c.74% of Australia) is used for extensive grazing by sheep and cattle. However, Australia differs from the Near East-North African Region in that it has a substantial potential to expand the existing areas of crops and sown pastures by further clearing of forests and scrub (Davies and Eyles 1965). It is not unrealistic to envisage a crop and sown pasture area of 100 M ha (13%) in Australia. Furthermore, with only 14 M people the population pressures in Australia are far less than in most of the Near East and North Africa. This allows types of farming systems in Australia which do not necessarily suit analogous climatic and edaphic areas in the Near East-North African Region.

While the problems of the crop and livestock industries in the Region are generally recognized, actions designed to rectify these problems are often grossly inadequate. However, there is widespread appreciation of the urgent need to produce more human food and livestock feed and to arrest the rapid deterioration of croplands and rangelands in the Region. Fertilizer use is increasing (Table 5), but in recent years the increased cost of nitrogenous fertilizers has caused a resurgence of interest in the potential role of pasture legumes and forage-crop legumes in addition to the food-crop legumes currently grown in the Region (Table 4). It should be emphasized here that the pasture legumes (e.g. medics or clovers), forage-crop legumes (e.g. alfalfa, sainfoin or vetch) or food-crop legumes (e.g. broad beans, chick peas or lentils) should be regarded as interchangeable in the farming system - depending on the needs, market potentials and scale of operations. Of course, the recognition of the value of legumes is not new: these have been cultivated since historical times (Harlan 1975, 1976; Carter 1977, Appendix C), but there is a new urgency about making good the deficits in human food and livestock feed and restoring the nitrogen status of the cropping soils.

The opportunity for inclusion of more legumes in the farming systems of the Region is closely related to the current widespread use of the cereal-fallow rotation. Each year some 45 M ha of fallow lies in a relatively unproductive state in the Near East-North African Region. In the nine countries covered in this report there are about 30 M ha of fallow each year (Table 14), but the extent to which this area is sown to legumes will depend on Government policies which will have to recognize the need for better crop-livestock integration.

The evolution of the cereal crop-fallow system (6-8 months crop, 16-18 months fallow) dates back to historical times. The actual duration of the tillage period including the seedbed-preparation phase of the fallow varies greatly - from less than 6 months to almost the full period of 18 months. Those areas that have traditionally adopted a short tillage period in preparation for the subsequent cereal crop are the best suited for inclusion of a legume in the rotation as minimal changes in programming are involved. The most common arguments in favour of the long fallow have been to: (i) rest the soil and improve the fertility; (ii) store water for subsequent crops; (iii) destroy weeds; (iv) control plant

diseases; and (v) spread the work load (when animal draught-power is involved). However, in many situations these stated aims of fallowing are invalid or no longer relevant: furthermore, the high costs of tillage associated with long periods of clean cultivation and the deleterious effects of tillage (especially when the soil is too wet or too dry) on soil structure, permeability and consequent erosion are often grossly under-estimated quite apart from the loss of valuable livestock feed during long periods of bare fallow.

In many areas of the Region the soils are too shallow for meaningful storage of water from one season to the next and even where there are deep soils, with adequate water-holding capacity, weeds are often deliberately encouraged as livestock feed. This reflects the fact that throughout the Region livestock are valuable and purchased feed both scarce and expensive. There is a constant conflict of interest between early ploughing of the fallow to ensure weed control and good seedbed preparation, and later ploughing to allow greater production and utilization by livestock of volunteer herbage species on the fallow lands. The difference between early and late ploughing may well amount to 1000-2000 kg DM/ha of livestock feed depending on site and season (see comments under III, 7. Turkey p.43). In assessing carrying capacity it is reasonable to assume 800 kg DM of pasture, etc. (with 85% utilization) as equating with 1 ewe equivalent on a year-round basis and 2/3 this amount for a dry sheep equivalent. Thus, in terms of saving of purchased fodder (frequently US\$100-150/t and sometimes more), or in terms of carrying capacity, the existing production from the weedy fallows is extremely important and cannot be ignored in any valid cost/benefit analysis of various farming systems. However, most fallow areas in the Region could produce much more livestock feed than at present: this is where various pasture legumes and forage-crop legumes have a potential multi-purpose role of great importance.

In view of the fact that most fallow areas in the Region are not controlling weeds, or storing significant amounts of water, and that with extensive mechanization the importance of spreading the workload is no longer relevant in many areas, it is logical to seek to modify existing farming systems to improve food and feed production and financial returns commensurate with preserving the long-term productivity of the soil. The southern Australian ley-farming system of using the self-regenerating annual pasture legumes in rotation with cereals, involving the close integration of crop and livestock production, has many advantages in terms of improving the quantity and quality of feed, increasing the levels of soil organic matter and soil nitrogen, improving soil structure and infiltration and greatly reducing the disease and weed problems in subsequent cereal crops (Carter 1974a,b and 1975a,b; Geytenbeek 1974; Leeuwrik 1974a,b and 1976; Oram 1974). The combined monetary returns from the integration of cereal crops and grazed leguminous pastures are far better than from the old crop-fallow system: many examples are available (e.g. Donald 1965; French, Matheson and Clarke 1968).

In relation to the widespread crop-livestock integration based on the use of self-regenerating annual legumes in southern Australia it should be emphasized that the system used in the cereal-livestock zone (250-500 mm rainfall) evolved over a period of some 20 years and that there is a considerable degree of flexibility in the rotation depending on relative demands for cereal crop or livestock products - especially meat (Carter 1975b). There is no suggestion that the small subsistence farmer in the Near East or North Africa should suddenly change his farming system to include grazed leguminous pasture: however, he may well substitute a crop of beans (food legume) or vetch (forage-crop legume) for his long fallow providing that he has sufficient labour and finance or credit for acquiring the extra inputs, particularly of seed and fertilizer.

The existing role of the self-regenerating, annual pasture legumes notably *Trifolium subterraneum* L. (subterranean clover) and *Medicago truncatula* Gaertn. (barrel medic) in southern Australian farming systems and the relevance of these integrated cereal-livestock systems to the Near East and North African Region will be discussed in the next section.

## II. RELEVANCE OF SOUTHERN AUSTRALIAN FARMING SYSTEMS TO THE REGION

### 1. The Stratification of Agriculture in Southern Australia

The Near East-North African Region and southern Australia, both with Mediterranean-type climates, have many similarities in soils and in existing and potential land use. Therefore, many of the lessons that have been learned in Australia over the last 100 years can apply to the arid rangeland, steppe, the semi-steppe and adjacent cereal cropping zones of the Near East and North Africa.

In Australia there has been a deliberate policy of reducing both livestock numbers and human population in the arid and semi-arid areas: there has been a gradual retraction from the steppe zones and marginal cereal-growing areas to zones receiving more-assured rainfall. Likewise the most reliable method of preserving the productivity of the arid rangelands and steppe zones of the Near East and North Africa is to reduce the livestock numbers and human population in these areas. This can be done by providing alternative sources of livestock feed i.e. by greatly increasing pasture and forage crop production in the traditional rainfed and irrigated crop zones and higher-rainfall areas of the Region. There is great potential for increasing both livestock and crop production in the Region while, at the same time, reducing grazing pressure on the steppe, and eliminating the serious water erosion problems of much of the cereal-producing areas and higher-rainfall hill country. The traditional dichotomy in ownership of land and livestock in the Region makes it difficult to effect rapid changes with respect to integration of crop and livestock production. However, the current nomadic and transhumant livestock management systems contribute to overgrazing and erosion in most places and to undergrazing with consequent weed problems in other areas. These factors act as constraints to both cereal crop and livestock production.

There is a clear need to reduce grazing pressure on the steppe rangelands of the Region and this can be achieved by providing alternative grazing for flocks and herds in the cereal and high-rainfall zones just as is the case in southern Australia where the sheep and cattle industries are stratified as follows:

- (i) Arid and Semi-arid Pastoral Zone (125-250 mm mean rainfall)
- (ii) Cereal-Livestock Farming Zone (250-500 mm mean rainfall)
- (iii) Higher-rainfall Grazing Zone (>500 mm mean rainfall)
- (iv) Irrigated Crop and Pasture Zone

There is a well-established annual movement of surplus young sheep and cattle and older breeding stock from the pastoral land in southern Australia (which is analogous to the *Artemisia herba-alba* steppe of the Near East and North Africa) to both the cereal-livestock and higher-rainfall zones for direct slaughter, to allow fattening prior to slaughter or, in the case of breeding ewes (or cows), to raise another one or two lambs (or calves) in a more-favourable environment with a more-assured feed supply. A limited number of lambs and young cattle are fattened on irrigated pastures. This is an efficient system of interzonal complementarity: it suits landholders in each of the four zones. It maintains the arid and semi-arid shrub steppe zone essentially as a breeding area and it ensures conservative stocking in this zone. This Australian example of interzonal complementarity or interdependence has direct relevance to many areas in the Near East and North Africa.

The stratification of agriculture in southern Australia into three main zones, with the irrigated zone forming an important but quite minor area, evolved during the last 100 years when initially there were no weather records. Hence there were mistakes: native shrub steppe of *Atriplex* spp. and *Kochia* spp. in the pastoral zone was ploughed for wheat crops in the early days of settlement: other areas of shrub steppe were destroyed by overgrazing. Now these areas are conservatively stocked with sheep and cattle under Government leasehold (licence) and livestock numbers are controlled. There is no cropping of these rangelands in the dry pastoral zone areas. Human and livestock population in these rangeland areas and marginal cropping areas (c.250 mm rainfall) has been gradually decreased

through various opportunities for resettlement in more reliable rainfall areas.

The closely integrated crop and livestock enterprises for typical cereal-livestock farms in Australia are summarized in Appendix A, Table 2. It should be noted that the South Australian and Western Australian cereal-livestock farms are the most relevant to the Near East-North African Region though some farms in Victoria and New South Wales (in the winter-rainfall areas) are also relevant. As mentioned previously, the crop-livestock system as implied in this table has considerable inbuilt flexibility depending on market demands and potential profitability of crop or livestock products. Clearly, the ability to rapidly build up a cattle herd is much more restricted than in the case of a sheep flock.

## 2. Evolution of the Ley-Farming System in Southern Australia

The role of the self-regenerating, annual pasture legumes notably subterranean clover and barrel medic in southern Australian agriculture has been well-documented (e.g. Carter 1965, 1975b; Donald 1965, 1970). The possibility of transferring the southern Australian technology of establishment and management of these legumes to North Africa and the Near East has been examined sporadically over the past twenty years or so (Gallacher 1972, Carter 1974b, 1975a) but recently there has been renewed interest. To assist in evaluating the relevance of the southern Australian ley-farming system to the Near East-North African Region it seems appropriate to briefly review the evolution of the role of the self-regenerating annual legumes in integrated cereal-livestock farming systems in southern Australia.

Following the official South Australian settlement in 1836 cultivation of soils for wheat growing and the grazing of native perennial grass pastures (e.g. *Themeda*, *Danthonia* and *Stipa* in savannah woodland communities) or chenopodiaceous shrub steppe (e.g. *Atriplex* and *Kochia*) spread rapidly. However, the initial native fertility of the soils was soon depleted and yields of wheat declined through nitrogen and phosphorus deficiencies. Donald (1965) quoted a decline in wheat yield from 860 kg/ha in the 1870's to 490 kg/ha in the 1890's for Australia while the yields were even lower in South Australia (Cornish 1949). Australian farmers are renowned as innovators, and though this first phase of cropping history was one of exploitation it also saw the development of Ridley's stripper in 1843, Smith Bros. stump-jump plough in 1876 and McKay's stripper-winner in 1885. Because of these and other innovations there has been a steady rise in agricultural machinery manufacturers in Australia (Carter and Saunders 1970).

The second definable phase in Australian cereal-crop history was the period from c.1900-1930 which period saw the impact of Farrer's new wheat varieties, and the use of superphosphate and bare fallowing. Though wheat yields increased from about 1900 to the 1920's they were falling again in many areas by 1930. In these areas the wheat-fallow rotation had depleted soil organic matter levels, soil structure had deteriorated and soil erosion was common.

The third phase of southern Australian agriculture has developed following the recognition of the benefits of incorporating annual, self-regenerating species of *Trifolium* and *Medicago* into our cereal crop rotations. Though Howard had discovered and marketed subterranean clover (*Trifolium subterraneum* L.) near Mt. Barker, South Australia, during the period 1894-1907, it took 30 years before full official recognition was given by the South Australian Department of Agriculture (Spafford 1924). This marked the beginning of subterranean clover as a really commercial legume in Australia and in the world. Meanwhile various legumes were being evaluated in the cereal belt, but by 1938 Trumble and Donald had concluded that although subterranean clover was unsuited to the drier and more alkaline soils of the cereal belt the annual *Medicago* species were promising. The following year barrel medic was recommended for the calcareous soils of the cereal belt in South Australia (Trumble 1939). This represented the beginning of the commercialization of barrel medic *Medicago truncatula* Gaertn.) formerly *Medicago tribuloides* Desr. in Australia and in the world.

It is important to stress that both the annual *Trifolium* species and annual *Medicago* species were originally accidental introductions from the Mediterranean Region to Australia, just as were most of our weeds (Appendix A, Table 4). Furthermore, it is important to emphasize that edaphic factors as well as climatic factors have been of major importance in determining the natural spread of these accidentally-introduced, self-regenerating annual pasture legumes in southern Australia. In South Australia, following the widespread drilling of superphosphate with wheat and the topdressing of superphosphate on native perennial grass (*Danthonia-Stipa*) pastures in the 1920's, there was a rapid spread of *Medicago* spp. on the calcareous soils of the cereal belt and of *Trifolium* spp. on the neutral to acidic soils in the higher-rainfall areas. Hence there were tens of thousands of hectares of naturalized medics (especially *Medicago polymorpha*, *M. truncatula* and *M. minima*) and clovers (especially *Trifolium subterraneum* and *T. glomeratum*) long before there were any named cultivars of these species in Australia (Barnard 1972). At present both subterranean clover and barrel medic play a vital role in cereal crop rotations in southern Australia - subterranean clover for the wetter areas with neutral to acidic soils and barrel medic (and other medics) for the drier areas with neutral to alkaline soils (e.g. Amor 1965, 1966; Robson 1969; Scott and Brownlee 1970).

Though the value of legumes as nutritious food and forage crops, and for soil rehabilitation, has been recognized for thousands of years, the use of self-regenerating annual species of *Trifolium* and *Medicago* in cereal crop rotations is an Australian (especially South Australian) development, and these legumes make a major contribution to both livestock feed supply and to soil nitrogen. This legume-cereal rotation (or ley-farming system) in South Australia started in the 1930's, developed in the 1940's and became well-established in the 1950's (Callaghan 1958, Donald 1965). Prior to this period the cereal lands had been exploited with frequent cropping on fallow, soil fertility was depleted, soil structure had deteriorated and soil erosion was common. The development of the ley-farming system was possible through a reduction in the area of bare fallow, increased use of superphosphate, increased areas of barley (and relatively less wheat), and also the adoption of shallow tillage practices to avoid burial of legume seeds too deep for subsequent emergence. In part, the reduction in wheat growing was due to the economic depression of the 1930's. This integrated pasture-livestock-crop system gave increased yields of cereals and greatly increased livestock numbers, better protection of soil, and a far more stable farm income.

The pasture and forage crop legumes, notably subterranean clover (*Trifolium subterraneum*), the annual medics (mainly *Medicago truncatula*) and the perennial alfalfa (*Medicago sativa*) in southern Australia, and *Stylosanthes* spp. and other tropical legumes in northern Australia, form the basis of some 28 M ha of sown pasture and guarantees the main feed supply of some 180 M sheep equivalents each year. The net increment of soil nitrogen resulting from symbiotic nitrogen fixation varies with productivity of the leguminous sward being generally in the range 50-150 kg N/ha/annum. This nitrogen accumulated under grazed pasture provides the major nitrogen requirements for cereal crop production as well as maintaining the ongoing productivity of the permanent pastures in the higher-rainfall areas. The annual increment of soil nitrogen from grazed leguminous pastures in South Australia, based on an assumed net input averaging 70 kg/ha, is currently worth c.US\$80 M and in the whole of Australia c.\$800 M (Carter 1975b).

Under South Australian conditions, net nitrogen fixation frequently exceeds 100 kg N/ha/annum or 3 to 4 kg N/kg P<sub>2</sub>O<sub>5</sub> applied (Carter 1970), especially in the higher-rainfall areas. However, a fair estimate of a mean nitrogen input for our cereal-livestock zone and higher-rainfall areas is 70 kg N/ha/annum. In the cereal belt, this nitrogen is utilized by crops in the rotation. In the higher-rainfall regions, the legume nitrogen is utilized by sown or volunteer pasture grasses or non-leguminous weeds.

Examples of typical rotations in the cereal belt are:

- (i) Medic-wheat-medic-wheat )
- (ii) Medic-barley-medic-barley) (short rotation: medic not re-sown)
- (iii) Medic-barley-barley-medic)
- (iv) Sub.clover<sup>+</sup>-sub.clover-sub.clover-wheat-barley-barley  
(long rotation: sub.clover generally re-sown)

Following the commercialization of Howard's subterranean clover in 1907 (subsequently given the cultivar name of Mt. Barker) and of the first selected line of barrel medic (subsequently given the cultivar name of Hannaford) many other naturally-occurring ecotypes (i.e. naturalized from accidental introductions) of both species have been studied and named (Barnard 1972). It should be emphasized here that no native Australian legumes have been suited for use as crops or sown pastures. An active Plant Introduction Programme (jointly operated by the CSIRO and State Departments of Agriculture in Australia) has also been responsible for the deliberate introduction of new genotypes, many leading to new cultivars of existing species and also new species of *Trifolium*, *Medicago*, etc. (Barnard 1972). Because of the climatic and edaphic analogies the programme of plant introduction to southern Australia has relied heavily on the Near East-North African Region - particularly the Mediterranean Basin and several official expeditions of plant exploration and collecting have been organized (e.g. Smith 1955; Crawford 1967, 1977; Broue *et al.* 1975). In the milder-winter areas (i.e. more coastal areas) of North Africa and the Near East, annual *Medicago* species are most common because of the dominance of calcareous soils though the sub-species *brachycalyceinum* of subterranean clover is common (Heyn 1963; Katznelson 1970, 1974; Barnard 1972; Carter 1974b, 1975a; Francis, Katznelson and Collins 1975).

There are now numerous well-documented examples of the multiple benefits of using either *Medicago truncatula* (and other medics) or *Trifolium subterraneum* in the crop rotations on cereal-livestock farms in southern Australia. These annual pasture legumes have a multi-purpose role in improving soil fertility (soil nitrogen, soil organic matter, structure and permeability), providing high-protein feed for grazing livestock, helping to control weeds through direct competition and through grazing, and helping to control cereal diseases, e.g. cereal root rots. However, the range of medics and clovers is being constantly extended in the ley-farming system. Furthermore, the recent arrival to southern Australia of pests like sitona weevil (*Sitona humeralis*), the spotted alfalfa aphid and the blue-green aphid are causing a re-look at sources of tolerance within the huge range of germplasm available (e.g. Crawford 1970, 1973, 1975). Thus the species and cultivar recommendations must be quite dynamic for any agricultural district.

In addition to the above pasture legumes there are extensive areas of alfalfa in southern Australia and substantial areas of lupins (especially on the acidic sands of Western Australia) also renewed interest in the vetches and other forage-crop legumes. Furthermore, there is increasing interest in large-scale production of *Vicia faba* and other grain legumes. Thus there is not only flexibility in the cereal crop-livestock combinations but also an increasing flexibility in the legume base of the southern Australian integrated cereal-livestock farming systems, all of which have relevance to the Near East-North African Region.

Three vital components of the successful use of the self regenerating medics and subterranean clover in southern Australian ley-farming systems are: (i) the adoption of shallow tillage practices; (ii) the use of adequate soluble phosphatic fertilizers; and (iii) proper grazing management. However, in the Near East and North Africa deep ploughing, inadequate use of phosphatic fertilizers and poor grazing management are currently major constraints to successful adoption of southern Australian ley-farming practices.

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<sup>+</sup> Sub.clover is the standard Australian abbreviation for subterranean clover.

### 3. Tillage Practices in Southern Australia, the Near East and North Africa

The several major constraints to agricultural production in the Near East and North African Region have been discussed in previous reports (Carter 1974b, 1975a,b; 1977, Appendix C) and will not be reviewed here as most of these are referred to in later parts of this report. However, the broad problems of tillage practice deserve special mention: further details are given by Sims (1977).

The historical evolution of bare-fallowing (implying long periods of clean cultivation) in the Near East-North African Region has been referred to elsewhere and the purpose of fallowing to allow accumulation of soil water in deeper soils with reasonable water-holding capacity and to accumulate some soil nitrogen for the subsequent crop has some merit in dryland farming areas, including southern Australia (Rooney, Sims and Tuohey 1966; Kohn, Storrier and Cuthbertson 1966). However, many of the cereal-producing soils of southern Australia and in the North African-Near East Region are too shallow to give significant storage of soil water through summer (French, Matheson and Clark 1968). The potential advantages of clean-cultivated fallow must be balanced against the disadvantages which include high costs of additional tillage, deterioration of soil structure and loss of potential livestock feed. With extensive mechanization of tillage and sowing operations, and the availability of pre- and post-emergence herbicides, the need for early soil preparation (i.e. long cultivated fallow) has diminished (Fisher 1962a, b) though it is certainly convenient to have some prepared fallow to allow a greater spread of sowing and reaping operations.

Experience in southern Australia shows that there are no advantages from deep tillage and there seems to be no scientific basis for the widespread farming practice of initial deep ploughing in preparation of the seedbed in the fallow lands of the Near East and North Africa. Because of the slowness of the deep-ploughing operation, soils are often ploughed when outside the optimum range of soil moisture; thus deep ploughing is not only costly but also contributes to the problem of poor soil structure in the Region. But, given the poor soil structure, no doubt the deep ploughing (commonly 25-30 cm) with consequent rough soil surface allows more time for infiltration of water (Carter 1974b, 1975a). There is no doubt that deep ploughing has largely eliminated, and will continue to eliminate, the valuable self-regenerating annual pasture and forage-crop legumes (e.g. species of *Medicago*, *Trifolium* and *Vicia*) from the cereal lands in the Near East and North Africa (Carter 1974b, 1975a) because early (spring) ploughing prevents seed production by these legumes and late (autumn) deep ploughing after seed maturity eliminates the legumes through deep burial of the seed. While the annual medic species in particular have a high percentage of hard seed (i.e. impermeable seed, Quinlivan 1965, 1971) which is softened by burial in the soil, ploughing and subsequent tillage must aim at keeping a high proportion of the seed sufficiently near the soil surface to allow germination and emergence of seedlings. A ploughing and general tillage depth not exceeding 8-10cm is adequate in southern Australia and should suffice in most cereal-growing areas of the Near East and North African Region (Chambers 1961, 1962, 1963; Rooney, Sims and Tuohey 1966; Carter 1974b, 1975a). Deeper mouldboard ploughing is rarely needed (Carter and Saunders 1970).

In the Near East and North Africa tillage and sowing implements need the following features: (i) stump-jump construction - to allow passage over solid obstacles without damage; (ii) clearance - to handle trash and allow passage over solid obstacles; (iii) strength - for long life and minimal maintenance; (iv) wheeled - for proper depth control and to provide a levelling action; and (v) width - for rapidity of operation and to provide a levelling action. In southern Australia a plough is not essential equipment in much of the cereal belt and implement size is matched to farm size: the same should apply in the Near East and North Africa. The utility of various implements including those shown in Plate 1 and Figure 2 were detailed previously (Carter 1974b; 1975a,b): tyned implements have special advantages in levelling and preparing an ideal seedbed (Carter and Saunders 1970) and should replace disc implements where possible.

PLATE 1

Typical South Australian tillage and sowing implements used on cereal-livestock farms. The stump-jump mechanism which allows discs or tynes to pass over solid obstacles (e.g. rocks) without damage, functions through compression of a strong spiral spring in each of these three implements though springtyne cultivators (scarifiers) are common, especially in the wider, lighter-draught implements. Note the wheels for depth control, the width of implements and the shallow tillage. The spring-release combine (combination drill and cultivator) shown with typical light trailing harrows has three optional, easily-changed undercarriages, *viz.*, spring-tyne, trash-discer and disc-drill undercarriages.

(Photographs: Original prints from John Shearer and Sons Ltd., Kilkenny, South Australia).

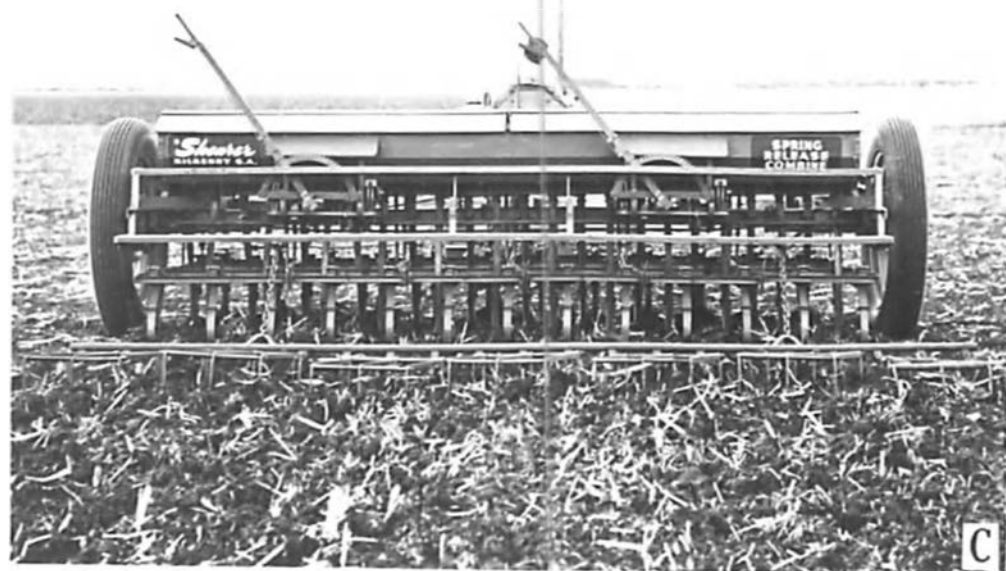
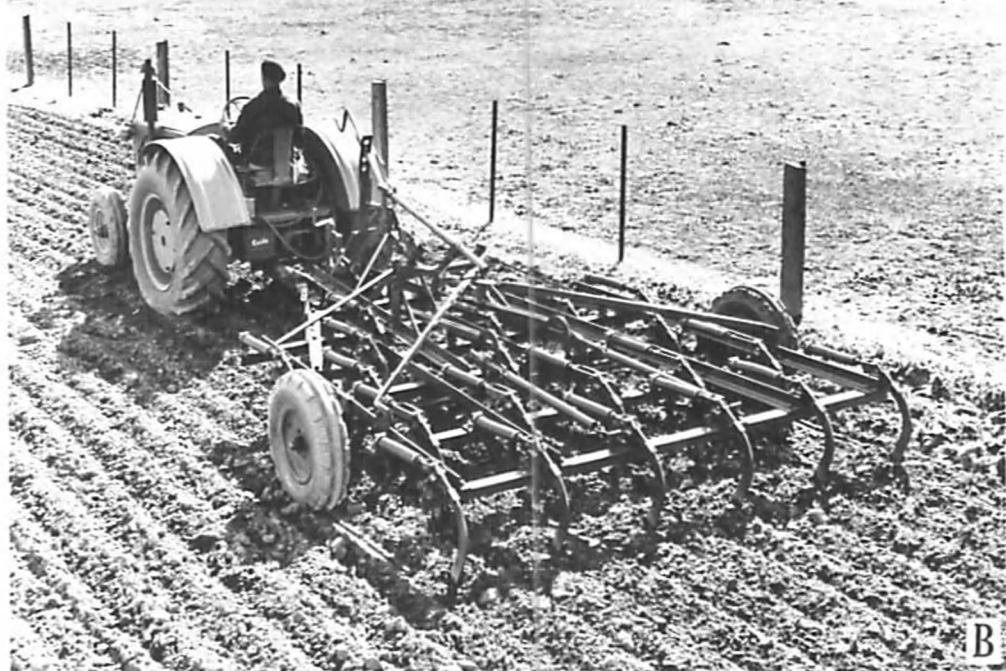
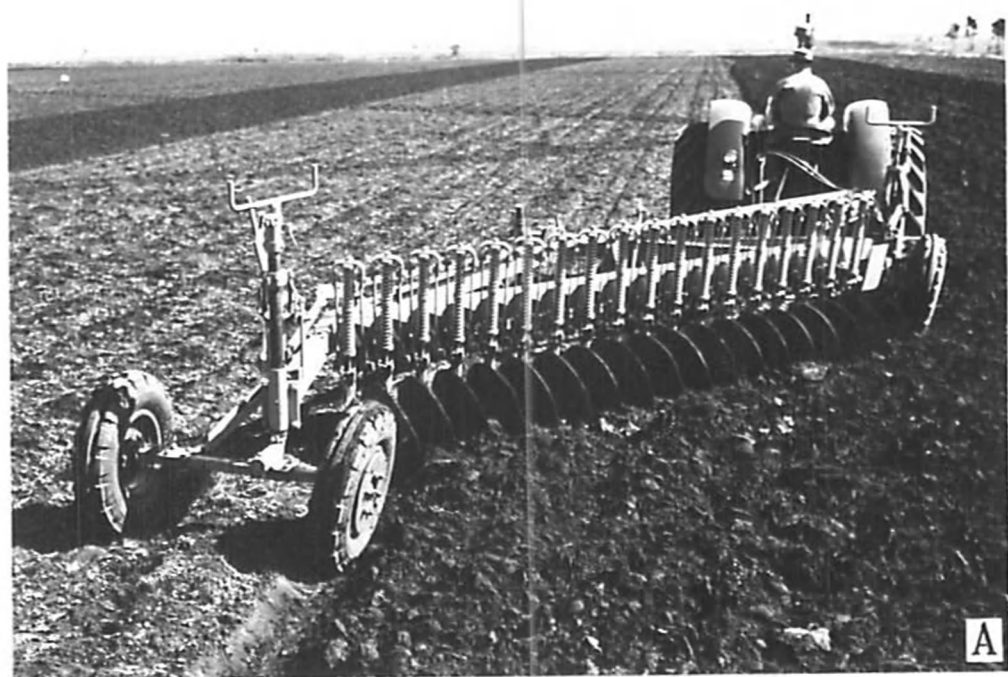
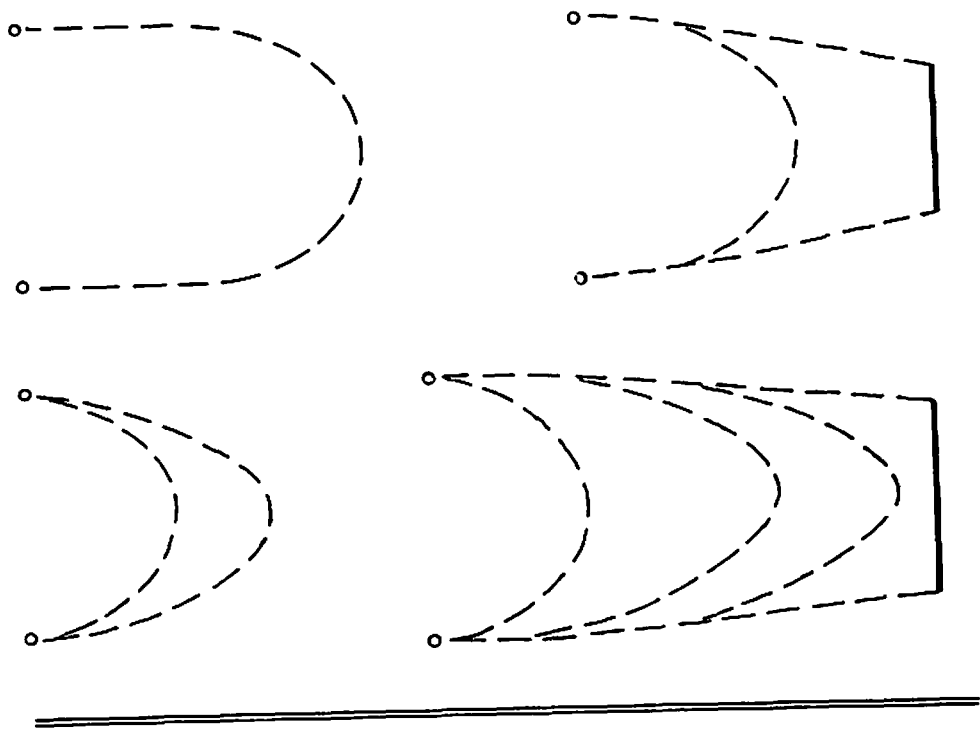


FIGURE 2

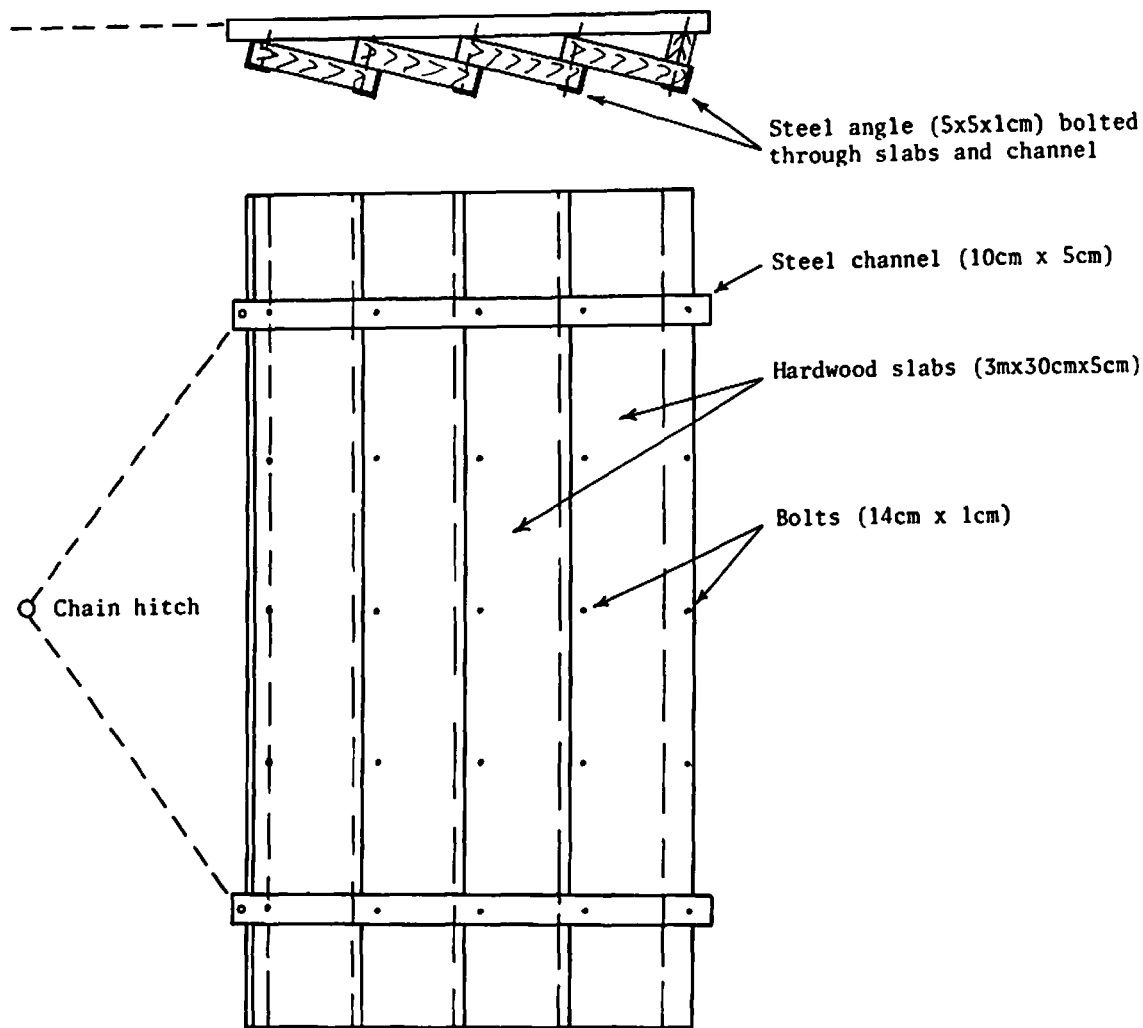
Upper: Typical chain rigs for clearing trees or shrubs or for the preliminary levelling and consolidation of newly-ploughed or ripped land. Simple chain rigs (without spreader) will effectively row tree stumps, rocks, etc., providing the tractors are not travelling too far apart.

Lower: A typical slab leveller designed for use with a medium-powered tractor. The height of hitching the tractor will determine the volume of soil 'carried' in front of the leveller and available for filling depressions in the soil surface.

TYPICAL CHAIN RIGS



TYPICAL SLAB LEVELLER



### III. THE EXISTING AND POTENTIAL ROLE OF PASTURE AND FORAGE-CROP LEGUMES

#### 1. Algeria

This brief account of Algeria is based largely on previous visits in 1973 and 1974, and reports (Carter 1974a,b and 1975a) together with more recent discussions both inside and outside Algeria. The analogies between Algeria and South Australia with respect to the predominant calcareous soils, the climate and the weed floras in the cereal zone (Appendix A, Tables 3,4) suggest that there are no serious ecological constraints preventing pasture and forage-crop legumes fulfilling the same role in Algeria as in South Australia. However, in terms of land use and agricultural practice there are three major differences: Algeria has far less sown pasture, uses far less phosphatic fertilizer, and has a far greater percentage of fallow to crop land than does South Australia. These facts are reflected in the greater livestock numbers and cereal yields in South Australia than in Algeria (Appendix A, Table 5) but the farming practices in the cereal zone of Algeria are undergoing rapid changes.

From Appendix A, Table 3 it appears that altitudes in the *Medicago* areas are commonly greater in Algeria than in southern Australia. This is so. However, it is important to realize that there are substantial elevated areas in the eastern highlands of Australia (particularly the Northern Tableland and Southern Tableland areas of New South Wales) that experience cold winters. But, as the soils in these regions are acidic, the volunteer legumes are *Trifolium* spp, and the main sown legume is subterranean clover (*Trifolium subterraneum*). Normally the major farming enterprise involves sheep and beef raising on sown pastures with less emphasis on cereal cropping. Climatic data from these colder Australian regions are shown in Appendix A, Table 6. These cold areas have analogies in both the North African and Near East countries.

In Algeria the IDGC (L'Institut de Developpement des Grandes Cultures) has a dynamic multidisciplinary programme to improve cereal production and increase livestock feed. Australian cultivars of annual medics viz. *Medicago truncatula* cvv. Jemalong and Borung (barrel medic); *M. littoralis* cv. Harbinger (strand medic); *M. rugosa* cv. Paragosa (gama medic); *M. scutellata* (Commercial snail medic) and *M. tornata* cv. Tornafield (disc medic) have been sown. On the high plateau of Algeria, local ecotypes of annual medics with good cold-tolerance are, not surprisingly, superior in performance to Australian cultivars (Adem 1974; Carter 1974b, 1975a; Saunders 1976). However, Borung medic is reportedly more cold tolerant than other Australian cultivars. The local ecotypes of annual medics are being carefully evaluated prior to seed multiplication for broad-scale sowings.

The traditional segregation of cereal cropping and livestock production has led to problems of insufficient numbers of sheep to graze at high density for short periods to control weeds in newly-established medic in Algeria in the late winter and early spring (Carter 1974b; Webber 1975). Much could be done with some light-weight prefabricated fencing (that can be simply rolled for transport) and steel fence droppers to erect simple fences to assist grazing control of new-sown medic areas. The weed problem in North Africa (and the Near East) has to some extent been perpetuated to ensure feed for livestock but most weeds can be controlled with well-timed, shallow tillage and herbicides (Nelson 1976). Once the livestock feed supply is guaranteed then much needs to be done in the way of selection and management to improve the productivity of sheep flocks in Algeria (Jefferies 1977).

Of the total crop area of Algeria in 1975 (3.49 M ha) there were 3.03 M ha (86.7%) of cereals and only 99,000 ha (2.8%) of legumes comprising chickpeas, lentils, vetches, etc. Though the area of food legumes may well increase, the main increase in legumes is likely to be from the widespread use of annual *Medicago* spp. (both sown and volunteer). Carter (1974b, 1975a) estimated that each year productive annual *Medicago* pastures could replace various kinds of fallow on 2.5 M ha and that this could lead to an annual increase of 10 M t DM

of high quality green pasture, dry pasture or hay which could feed an extra 10 M ewe equivalents per year and provide a soil nitrogen increment of 60 kg/ha or 150,000 t N per year in addition to controlling weeds through competition and live-stock grazing, improving soil structure and infiltration, and improving cereal yields. It is probably more realistic to assume that the aforementioned 10 M t DM could support 12.5 M ewe equivalents. Furthermore, the increased availability of cereal straw should amount to an additional 1.2 M t. Thus there is potential to grow additional feed sufficient for 14 M ewe equivalents.

However, to achieve these potential increases in the cereal zone of Algeria there will be need for substantial investment in the following:

- (i) agricultural machinery of rugged construction and incorporating the SJ principle designed for rapid, shallow tillage and sowing operations;
- (ii) additional soluble phosphatic fertilizer;
- (iii) purchase or growing of annual *Medicago* seeds;
- (iv) fencing and water supplies for farm livestock; and
- (v) training in pasture-livestock management.

In addition to the potential for 2.5 M ha of annual medics each year in the traditional cereal zone (6.0 M ha) of Algeria there is considerable scope for pasture improvement in the higher-rainfall, hilly areas of north-eastern Algeria where there is potential to carry an additional 10 M ewe equivalents on semi-permanent, legume-grass pastures. Depending on location, soil and drainage, volunteer legumes in this region include *Medicago* spp. also *Trifolium fragiferum*, *T. pratense*, *T. repens* and *T. subterraneum* together with volunteer grasses including *Lolium perenne*, *L. rigidum*, *Festuca* spp. *Dactylis glomerata* and *Phalaris tuberosa*, all of which species are native to this region of Algeria. In many areas all that is required is superphosphate application and proper grazing management (Carter 1965, 1970, 1974b, 1975a). While the prospects for expansion of dryland farming in Algeria are not good (Downes and Faunce 1973) and there are excessive numbers of people and livestock in the steppe, these humid areas of north-eastern Algeria (Bounaga, Chaumont and Paquin 1971) are under-used but well suited to livestock production (including dairying) on improved pastures. Yet, despite the various national and international agricultural research programmes dealing with pasture and forage-crop species (e.g. Le Houerou 1971, 1972; Maignan 1971; Gallacher 1972), there has been little progress in pasture improvement in Algeria until recently. In large part this reflects the undue emphasis in the past on imported species and ecotypes. In particular, until recently, there has been negligible research devoted to the ecology, production, management and utilization of the wide range of indigenous annual species of *Medicago* existing in Algeria (Carter 1974b, 1975a).

Research priorities related to the production and utilization of annual *Medicago* species in Algeria were outlined by Carter (1974b, 1975a). Some of this research has now been done at the Waite Agricultural Research Institute, South Australia (Carter and Adem unpublished; Adem 1977<sup>+</sup>). Studies on the interrelationships of density (using sowing rates of 1,5,10,50,100,500 and 1000 kg/ha) and time of sowing of *Medicago truncatula* cv. Jemalong have shown yields exceeding 11 t DM/ha and clean-seed yields up to 1100 kg/ha. Experiments on the interrelationships of seed size (large, medium and small) and depth of sowing (10,30 and 50 mm) in terms of rate of emergence, total emergence and early growth of *Medicago scutellata* (Commercial), *M. rugosa* (cv. Paragosa), *M. truncatula* (cv. Jemalong) and *M. littoralis* (cv. Harbinger) have shown a progressive reduction in seedling emergence, cotyledon area, and seedling weight with both increasing depth of sowing and decreasing seed size. Studies on the digestibility of medic pods and survival of seed following ingestion of intact pods by sheep have confirmed earlier findings (Vercoe and Pearce 1960) and shown that for *M. truncatula*, *M. scutellata* and *M. littoralis* percentage survival of ingested seed was only 1.79, 1.97 and 1.34 respectively. Current feeding experiments involve other medics.

<sup>+</sup> ADEM, L. (1977). Studies on the ecology and agronomy of annual *Medicago* species. M.Ag.Sc. Thesis, University of Adelaide, 171p. (Degree Awarded May 1978).

PLATE 2

Overgrazing of hill country, cropping and overgrazing in the steppe, and the traditional separate ownership of land and livestock contribute to declining grazing and crop-land resources in the Near East-North African Region. Encouragement of self-regenerating annual *Medicago* pastures through reduced depth of tillage and use of more superphosphate, or the sowing of leguminous forage crops e.g. *Vicia* spp., could eliminate several million hectares of long fallow and greatly enhance pasture and forage crop production in the cereal zones of the Region. This would allow reduced grazing pressure with a consequent reduction in erosion on hill country and steppe areas.

(Photographs: Algeria, April 1974).



PLATE 3

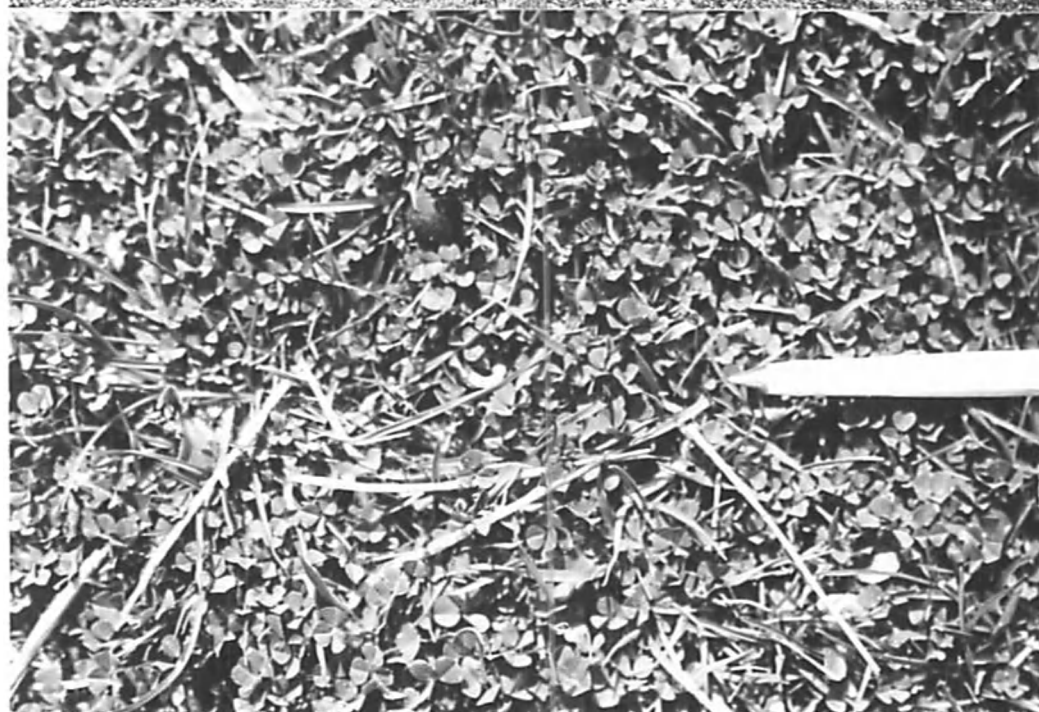
In Algeria many good areas of volunteer annual *Medicago* occur where land has remained undisturbed or where tillage has been shallow during the cropping years.

Upper photo: Well-grazed volunteer pasture of *M. polymorpha* and *M. truncatula* in the Constantine area.

Middle photo: Well-grazed volunteer medic pasture of *M. truncatula* and *M. polymorpha* on roadside contiguous to stubble land near Tiaret.

Lower photo: Typical cereal stubble area on land with a history of deep ploughing on a site immediately adjacent to the site of the middle photo (above).

(Photographs: Algeria, April 1974).



## 2. Tunisia

Field visiting in Tunisia was designed to supplement previous visits made in 1973 and 1974. Besides local visiting in the vicinity of Tunis the main field visit was via Mateur to the Integrated Rural Development Project at Sejenane in northern Tunisia.

Of the total crop area of 1.75 M ha in Tunisia (1975) about 1.48 M ha (84.7%) was sown to cereals and only 130,000 ha (7.4%) to leguminous crops. However, in recent years significant areas of Australian cultivars of annual medics have been sown to replace or supplement the traditional weedy fallow in the cereal belt (Gachet and Elmir 1972; Doolette 1976; Jaritz and Gachet 1976; Le Houerou and Froment 1977).

As was the case in Algeria, the striking resemblance between the native weed flora of the Tunisian cereal lands and the naturalized weed flora of the South Australian cereal-livestock zone lends support for the general applicability of the South Australian ley farming system in Tunisia. Serious weeds of cereal crops in Tunisia and South Australia include: *Avena sterilis*, *Convolvulus arvensis*, *Diploaxis* sp., *Lolium rigidum*, *Oxalis pes-caprae*\*, *Papaver rhoeas*, *Rapistrum rugosum*, *Raphanus raphanistrum*, and *Sinapsis arvensis*.

The annual medics are being actively promoted in the Tunisian cereal zone receiving 350-500 mm mean annual rainfall while in the wetter districts it is common to use vetch-oats mixtures for hay. Strawberry clover (*Trifolium fragiferum*) and tall fescue are used in wet depressions while alfalfa is used to some extent where there is adequate water but no waterlogging.

During the last few years both local ecotypes of annual medics and Australian cultivars have been evaluated in field experiments. Of the Australian commercial lines, *M. truncatula* cv. Borung and Jemalong; *M. rugosa* cv. Paragosa, *M. littoralis* cv. Harbinger and *M. scutellata* (Commercial snail medic) have been the most promising. On the heavier soils, Borung has consistently given the highest total yields but Jemalong has given more winter production so Jemalong is recommended for the heavier soils. On the other hand, Harbinger has proved best of the commercial cultivars on the lighter-textured (sandy) soils. Hence Jemalong and Harbinger continue to be the main medics sown in Tunisia. Snail medic, because of the extremely high percentage of hard seed and because sheep and goats easily prehend its large pods in summer, tends to give poorer re-establishment than *M. truncatula* or *M. littoralis*. Paragosa medic must be furnished with the appropriate *Rhizobium* inoculum otherwise it will not nodulate properly; it has also shown to be sensitive to waterlogging.

The Sejenane project area in the wetter areas (700 - 1500 mm) of northern Tunisia at present comprises 75,000 ha which is planned as 20,000 ha of sown pasture and forage crops mainly based on subterranean clover (*Trifolium subterraneum*); 30,000 ha of natural and planted forest where *Eucalyptus gomphocephala* (Tuart) is planted for fuel, shade and shelter; and 25,000 ha of annual crops. In some of the wetter sites perennial legumes e.g. *T. repens* are being sown. There would appear to be considerable scope for expansion of the Integrated Rural Development Project sown pasture area on which the carrying capacity should be 10 ewe equivalents per hectare.

In the cereal zone of Tunisia it is realistic to envisage 1.2 M ha of fallow being used each year for production of leguminous pastures or forage crops with a potential mean increase of 4000 kg DM/ha i.e., 4.8 M t of dry matter sufficient for 6 million ewe equivalents. There should also be an increased yield of cereal straw of 0.6 M t. Furthermore, there is scope for an additional 200,000 ewe equivalents in northern Tunisia where this potential increase should reach at least 1,250,000 ewe equivalents through brush clearing; sowing pasture

\*

Native of South Africa.

and using phosphatic fertilizer on the sown pasture and on some existing degraded pastures. Thus there is a projected realistic potential increase in sheep carrying capacity in the cereal zone of c. 6.75 M ewe equivalents and a total potential increase of 8 million ewe equivalents which could allow a considerable reduction of grazing pressure on the steppe rangelands providing that the socio-economic and administrative constraints to transfer of population and livestock from the arid southern areas of Tunisia to the cereal zone, and higher-rainfall areas of northern Tunisia can be overcome.

### 3. Libyan Arab Republic

Field visiting in Libya was confined to the Jeffara Plain Development Project on sandy soils in the Tripoli region also the sandhill reclamation project near Tripoli together with the Jebel El Akhdar Development Project based mainly on heavy-textured soils of the El Marj region of Cyrenaica. Visits were made to offices of the Ministry of Agriculture and Agrarian Reform and to two FAO Projects based in Tripoli.

Libya, with 492,000 ha of total crop (1975), had 418,000 ha (85.0%) cereals and only 13,000 (2.6%) of legumes. While there is little scope for increasing the area for cropping there is scope for sowing annual medics to replace the traditional weedy fallow areas. Five Australian commercial lines have been sown on very extensive areas in Tripolitania and Cyrenaica. *Medicago truncatula* cv. Jemalong, *M. littoralis* cv. Harbinger, *M. scutellata* (Commercial snail medic), *M. tornata* cv. Tornafeld and *M. rugosa* cv. Paragosa have all been sown for use in rotation with wheat and barley. Though these Australian commercial lines of medics have performed well, there is scope for using some promising early-maturing local ecotypes which might well prove superior in some situations just as was the case in Tunisia and Algeria.

The distribution of annual *Medicago* species in northwest Libya as reported by Khalil, Francis and Halse (1977) appears to be similar to that in Algeria (Carter 1974b, 1975a). Nine *Medicago* species representing collections from 10 sites in Libya showed that *Medicago laciniata* was the most common species collected; however, *M. truncatula* predominated on the heavier-textured soils with *M. tornata* and *M. littoralis* more frequent on sandy soils. The Libyan ecotypes were found to be typically early-flowering with a rapid rate of burr maturation. No doubt this reflects the brevity and uncertainty of the growing season in this region.

On the assumption that 400,000 ha of fallow are sown to medics which yield an additional 3000 kg DM/ha as pasture, or hay, this means an additional 1.2 M t DM. Improved cereal yields resulting from use of medics and additional fertilizers should give an increase of c. 240,000 t of straw. The total increased feed supply of 1.44 M t should support 1.8 M ewe equivalents per year.

The Department of Forestry, Range Management and Natural Resources have some spectacular sandhill reclamation projects near Tripoli and elsewhere. These are good examples of successful (although expensive) stabilization of dune sands through spraying of bitumen emulsion and planting of *Eucalyptus camaldulensis* and other eucalypt species also *Acacia cyanophylla*. This Department has also taken steps to prevent further degradation of the steppe rangelands by fencing some of these areas to control grazing and prevent cultivation.

Though there has been significant experimentation over the years this has centred mainly on crop agronomy and plant introduction and testing with emphasis on rangelands (e.g. Oram 1959; Soghaier 1959, 1961; Abu Sharr 1962; Le Houerou 1965). Of course this has not been peculiar to Libya; it has been the normal approach in the whole Region. However, the current programme of sowing annual medics in the cereal zones of Libya gives real hope of solving the livestock feed deficit, while providing some guidelines for crop-livestock integration and helping to stabilize rural incomes.

PLATE 4LIBYAN ARAB REPUBLIC

Left: Young eucalypt trees planted after spraying bitumen emulsion in a sandhill reclamation project near Tripoli. Some of the bitumen is still obvious.

Right: Older eucalypts on stabilized dune.

(Photographs: Tripoli district, April 1977).

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LIBYAN ARAB REPUBLIC

The drought conditions in the spring of 1977 in much of North Africa and the Near East are contrasted here on two sites in the Libyan A.R. which had each received about 100 mm of seasonal rainfall.

Left: On the clay-loam soils at El Marj there was a complete failure of the cereal crop through insufficient available soil water.

Right: On the sandy soils of the Jeffara Plain area, near Tripoli, cereal crop yields of c.1000 kg/ha were obtained in plots and paddock areas.

(Photographs: El Marj and Jeffara Plain, April 1977).

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TUNISIA:

There is an obvious livestock feed potential from both native types and introduced Australian medic cultivars in the cereal areas of Tunisia. Both situations will require superphosphate applications.

Left: Good volunteer stand of native annual *Medicago* spp.

Right: Sown annual medic comprising Australian cultivars.

(Photographs: Tunisia, April 1973).

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TUNISIA:

Left: Initial tillage using large offset discs on an area recently cleared from bush in the Integrated Rural Development Project at Sejenane. Costs of this operation could be greatly reduced either by using a double hitch to haul two sets of discs or by using a smaller crawler tractor.

Right: An area of first-year sown pasture based on subterranean clover and annual ryegrass in the Sejenane Project area.

(Photographs: Sejenane, Tunisia, April 1977).



#### 4. Jordan

Field visiting in Jordan covered the semi-arid hilly zone both north of Amman in the Jarash, Mafraq, Ramtha and Irbid areas to the Syrian border and south through Madaba to the Dead Sea area thence via Arair eastwards to the steppe plus a visit from north to south through the Jordan Valley zone to see the Deir Alla Agricultural Research Station and general land use of the Jordan Valley down to the Dead Sea. A more detailed description of these zones is given by Rafiq (1976). Discussions in Amman involved staff of the Ministry of Agriculture, The Ford Foundation, The Food and Agriculture Organization and the British Ministry of Overseas Development. Those sessions of the ICARDA/CIMMYT Barley Workshop of most relevance to the Region were attended.

With loss of control of the West Bank area of the River Jordan there is a serious deficit in arable land : *inter alia* this has resulted in dropping the permissible lower limit for cereal cropping from 250 mm to 200 mm. This has aggravated the problem of reckless ploughing of the steppe where the low and erratic rainfall results in poor yields quite apart from the fact that the expansion of cereal growing into the steppe automatically decreases the grazing area. In 1975 Jordan had a total crop area of only 207,000 ha which included 150,000 ha (72.5%) of cereals and 23,000 ha (11.1%) of legumes. Therefore, it is understandable that the problems of food security are of crucial importance to Jordan (also other countries of the Region) and this has influenced policies of self-sufficiency. Particular attention has been focussed on the instability of food production caused by unfavourable weather (mainly drought) in the dry farming areas of the Region.

Simaika has used wheat production in Jordan in a pilot study of food-security planning (ECWA/FAO 1977). Not surprisingly, these studies showed a high correlation ( $r = 0.93$ ) between annual rainfall and wheat production and the decreasing coefficient of variation (%) of annual rainfall with increasing annual rainfall. Bronzi (1977) has suggested that the coefficient of variation (%) for monthly and annual rainfall is higher in Jordan and Syria than in Tunisia and South Australia. The expectations of wheat yield in East Jordan were calculated by Simaika (ECWA/FAO 1977) as follows:

Area	Average Rainfall (mm)	Expected Yield (kg/ha)
Arid zone	100	46
Arid zone	150	133
Marginal zone	200	241
Marginal zone	300	472
Semi-arid zone	400	757

These studies showed that, while nothing can be done to change the rainfall, increased storage space of the order of 300,000 t with an initial stock of at least 100,000 t of wheat could greatly buffer against bad seasons in East Jordan.

One of the major constraints to agricultural planning in the whole Region is the apparent lack of data and/or documentation on land use capability - i.e. the interrelationships of rainfall, soil, slope, etc., in relation to potential crop, livestock or forestry enterprises and production. However, one example of a most useful document of this type is the "Report on Agricultural Zoning" in Jordan (Anon. 1974). This presents a clear picture of the agro-climatological zones in Jordan and related agricultural and socio-economic features of these zones.

Despite some good planning with regard to zoning according to agro-ecological zones, the range management, livestock production and cereal production groups within the Ministry of Agriculture are insufficiently coordinated. Hence the quest for greater cereal production has led to the ploughing of more steppe

rangeland : this is most unfortunate. Again there is insufficient coordination in the installation of watering points. Over-supply of watering points has led to excessive deterioration of the *Artemesia herba-alba* steppe. In some cases mobile water tanker-trailers can be most useful in allowing use of rangeland without pre-disposing the area to excessive grazing and treading damage. Another alternative is to have lock-up bores to ensure adequate resting of the rangelands. Of course the provision of water in dry areas is a sensitive socio-political matter and Jordan is not the only country of the Region where the competition for land use and the pressures from competing interests have been difficult issues. However, the rangelands of Jordan have suffered greatly from cultivation, overgrazing and the uprooting of trees, shrubs and grasses for fuel (Long 1957).

In Jordan, it has been traditional to grow barley on poorer sites or marginal rainfall areas for livestock feed also some areas of *Vicia ervilia* (bitter vetch) for grain, but yields of this vetch have been low and the grain harvesting slow, laborious and expensive. However, *Vicia narbonensis* (narbonne vetch), *V. dasycarpa* (woolly-pod vetch), *V. sativa* (common vetch), *Lathyrus sativus* (chickling vetch) and *Pisum sativum* (garden pea) have shown promise and have all out-yielded *V. ervilia*. Though *V. sativa* has been grown in mixtures with barley, under marginal rainfall conditions it has been disappointing and is best sown alone (Hopkinson 1975).

With regard to the development of improved pastures in Jordan, extensive testing has taken place in the Karak region (300-350 mm) and elsewhere (Bailey 1967). *Medicago scutellata*, *M. truncatula*, *Bromus mollis* and *Lolium rigidum* were most promising. Although the perennials, *Medicago sativa* (alfalfa=lucerne) and *Onobrychis sativa* (sainfoin), survived quite well under rainfed conditions, growth commenced late and total production was small. However, in the wetter area around Irbid there is considerable scope for growing forage-crop or food-crop legumes. In the Irbid area a wheat-lentil<sup>+</sup> rotation is common or, if >450 mm precipitation then a wheat-lentil-summer vegetable rotation may be used. Chickpeas<sup>+</sup> may be substituted for lentils in the rotation (Hopkinson 1975).

With the extreme pressures and competition for land use in Jordan there has been a substantial amount of research on agronomic practices by Oregon State University/USAID, the University of Jordan, the Ministry of Agriculture and by UNDP/FAO Projects which have continued for several years. Despite this bilateral and multilateral aid, mean wheat yields are very low - c.700 kg/ha. Most of this research effort has been centred on the Karak area - a hilly plateau of about 1000 m altitude typically with slightly-alkaline, well-structured, reddish-brown clays with a total water holding capacity of c.200 mm in the top metre of soil and mean precipitation of 300-350 mm falling from October to May.

In the Karak region, tillage for long fallows is often done when the soil is dry : consequently costs are very high. A further constraint is the fact that few farmers have seed drills. Wheat is broadcast by hand and generally covered by a light one-way disc resulting in densities of 25-110/m<sup>2</sup>. Though soils are very deficient in nitrogen (N) and phosphorus (P) frequently no fertilizer is used, even though 20 kg N/ha may well give a response of 180 kg wheat/ha (Greenfield 1977).

Some experiments indicated advantages from using deep-furrow drills. However, any experiments designed to assess various tillage and sowing procedures cannot be fully conclusive unless a very good range of implements is available and such experiments cover the important aspects of costs in relation to returns having regard to timing of operations, weed control, water storage, density/spacing relations. Experiments have shown substantial losses of soil moisture

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<sup>+</sup> Lentil = *Lens culinaris*. Chickpea = *Cicer arietinum*.

between February and August on prepared fallows. Where moisture is limiting early sowing of cereals e.g. November 15 is likely to give much better yields than later sowing, say December 15. This is completely analogous to the situation in South Australia where sowing of cereals after May 15 generally results in a measurable reduction in yield which declines progressively with later sowings. This particularly applies in the drier districts.

Because of the importance of timing of tillage and sowing operations which are always more critical in marginal rainfall areas, and the need for much more use of leguminous pastures and forage crops in the rainfed and irrigated zones, it is clear that more experiments are needed to evaluate the ecological and agronomic suitability of various legumes and the assessment of the socio-economic practicability of growing and utilizing these legumes in new systems which encourage much better crop-livestock integration. It seems highly probable that much better use of fallows for pasture and forage-crop legumes (and food-crop legumes) offers considerable scope for improving total livestock feed supply in Jordan. More-shallow, better-timed tillage operations, more-mechanized and better-timed sowing operations and increased fertilizer and herbicide use could greatly increase cereal production and allow retraction from the rangeland areas. There is every indication that by using more inputs both cereal production and livestock feed supplies could be greatly increased and thus improve and stabilize farm incomes. Here there is scope for the Jordan Cooperative Organization to help with credit and extension of new techniques to promote better methods. However, the amalgamation of fragmented holdings will be a necessary prerequisite to any substantial move toward mechanization of critically-timed tillage and sowing operations (Hopkinson 1975; Babb 1976; Greenfield 1977).

On the present cultivated lands in Jordan the average stocking rate is 2.28 sheep or goats/ha and on the steppe lands 0.129 sheep or goats/ha. Furthermore the stocking rate is 0.110 head of cattle/ha in the cultivated lands. Yet Jordan is importing 10,000 tons of red meat per year and 95% of livestock feed. Demirören (1972) in reviewing some of the problems of the sheep industry of the eastern Mediterranean has emphasized that feed shortage is the major constraint and that, with adequate feed and some selection, the indigenous breeds are of high fertility and have high lambing percentages, low mortality and good growth rate in lambs (Karam *et al.* 1971; Bhattacharya and Harb 1973). At present, rainfed agriculture comprises about 91% of cultivable land area of approximately 440,000 ha so that most of the potential increase in feed supply must come from the rainfed cropping areas : however there is scope for extra forage crop production in irrigated areas.

In Jordan, the production of more livestock feed is possible in several ways : firstly, by making better use of fallows for the production of pasture and forage-crop legumes; secondly, by ensuring greater output of alfalfa, berseem clover (*Trifolium alexandrinum*) and Persian clover (*Trifolium resupinatum*) on irrigated areas; and thirdly by the topdressing of phosphatic fertilizer on non-arable areas in the wetter districts to encourage growth of existing legumes including several species of *Medicago*, *Trifolium* and *Vicia*. Stimulation of these legumes will encourage nitrogen fixation leading to a general increase in soil fertility and greater pasture productivity and a consequent reduction in run-off and soil erosion. Increased feed supplies can decrease imports of feed and/or increase output per head of livestock products and/or allow some increase in livestock numbers. Certainly it must allow relief of grazing pressure on the steppe rangelands and other non-arable grazing areas which will allow slow regeneration of ground cover on these areas providing there is adequate exclusion of livestock and prevention of ploughing and unlawful cutting of trees and shrubs.

The following estimates of potential increases in livestock feed supplies are quite realistic given the appropriate inputs of seeds, fertilizer and other factors of production. On the assumption that 150,000 ha of fallow are used

for production of pasture and forage-crop legumes or legume-cereal mixtures giving a mean increase of 3000 kg DM/ha this would supply an additional 450,000 t DM. The use of legumes in the rotation plus the use of additional fertilizers could provide another 75,000 t DM as edible straw from 150,000 ha of cereals. The topdressing of superphosphate on 50,000 ha of non-arable hill lands should increase productivity by at least 1500 kg DM/ha. This would provide 75,000 t DM. Finally, it should be possible to increase the production of forage crops in irrigated zones by 40,000 t DM per year. Thus, there is a realistic potential to increase annual production of livestock feed by 640,000 t which can support 800,000 ewe equivalents.

This potential increase in feed supply approximates the needs of the existing ruminant livestock, flocks and herds in Jordan. Clearly, home-grown feed should be cheaper than imported feed so there are very good reasons for Government to lend full support to an integrated programme to raise cereal crop production and ensure livestock feed supply to make Jordan self-sufficient in meat and help stabilize rural incomes.

##### 5. Syrian Arab Republic

The visiting in Syria was designed to supplement that of a previous visit in 1973. Field trips in 1977 embraced the following areas: (i) from the Jordan border via Izraa Research Station to Damascus; (ii) Damascus region - Ministry of Agriculture Headquarters, Douma Research Centre and other research sites; (iii) Damascus-Homs-Hama-Aleppo with side visits to the Ghab Irrigation Area and El Kreim Research Centre for Sheep Improvement; and (iv) the Aleppo region and from Aleppo to north-east Syria via Raqqa, Deir-Ez-Zor, Hasakeh, Kamishly and Al-Malkieh to the Turkish and Iraqi borders (River Tigris). The crop ecological zones of Syria have been described by Rafiq (1976). These give a broad guide to the pasture and forage-crop potential in the various agro-ecological zones.

The serious Regional problem of increasing numbers of livestock being grazed on a diminishing area of deteriorating rangelands was emphasized in the preliminary report (Carter 1977, Appendix C). Probably the best example of a sustained and dedicated effort to reduce these problems has been provided by Draz and his national counterparts in Syria (Draz 1969, 1974a,b). Much has been done by way of organizing "Hema Grazing Cooperatives"; the establishment of range and sheep production centres; the establishment of feed stores at strategic points; the development of watering points and veterinary assistance; the establishment of a National Feed Revolving Fund and the provision of educational and health facilities for the Bedouin livestock owner and his children; however, much remains to be done to provide adequate feed to allow an overall meaningful reduction of grazing pressure on the steppe rangelands (Mo'Tassem 1972; Bhattacharya and Harb 1973).

The problems of the rangelands of Syria, which typify the general problems of rangelands in the Region, have been reviewed by Draz (1969, 1974a,b) who has emphasized the gross misuse of rangelands following the cancellation of traditional tribal grazing rights and the declaration of rangelands as National Grazing Lands for common use. There is no doubt that ancient grazing rights carried responsibilities concerning permissible stocking rates - these rules appear to go back to well before the birth of the Prophet Mohammed (Draz 1969) and it appears likely that the Hittites in the period c.1500 BC had rules relating to carrying capacity (e.g. Gurney 1952, p.81)<sup>+</sup>.

Draz (1974a,b) has estimated that about half the sheep population of Syria is owned by merchants and urban citizens and are shepherded by Bedouins with

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<sup>+</sup> See note under section on Turkey.

their own flocks to graze the free steppe rangelands. Although about one third of the steppe rangelands of Syria (including the more fertile parts) have been ploughed for grain production, no substitute of forage crop production on the higher rainfall or irrigated areas has been made available with the result that more animals are now grazing smaller areas of less-productive rangelands.

The dichotomy of animal and crop production was intensified by the Syrian Legislative Decree (No.65 of 1966) which enforced annual seasonal movement of sheep and goats from the cultivated areas to the steppe rangelands (approx. 7 months in steppe and 5 months grazing stubbles and weedy fallows). This apparent favouring of the crop producer has been offset to some extent by the Legislative Decree No.140 of 1970, which was concerned with prevention of ploughing of the steppe as part of the National Range Development Programme. Other more recent legislation defined the boundaries of the steppe and marginal lands. Thus Syria became the first country in the Region to support a genuine programme of conservation of the steppe.

One of the important lessons from the Syrian programme of rangeland improvement and stabilization of the nomadic sheep industry has been the clear demonstration of the prerequisite need to provide alternative feed supplies if the Bedouins are to reduce grazing pressure on the steppe. To this end much exploratory work with both introduced and local pasture and forage-crop species has been undertaken and the success of the various species in the differing regions of Syria documented e.g., the success of *Atriplex nummularia* and *A.leucoclada* in the steppe (Sankary 1976) and of *Vicia dasycarpa*, *V.narbonensis*, the Aleppo vetch type of *Vicia sativa* in the wetter districts.

Despite a long history of use of food-crop and forage-crop legumes in Syria, crop legumes (mainly pulses) accounted for only 237,000 ha (6.7%) of the total crop area (3.52 M ha) in 1975 whereas cereals occupied 2.75 M ha (78.3%). This percentage of legume remained almost unchanged for the 15-year period 1961-1975. Draz (1974a,b) and others have rightly advocated the replacement of fallow with pasture and forage-crop legumes and the Syrian Government in its 5-year plan 1975-80 has required a substantial increase in the area of vetch for the production of vetch-cereal hay. For example, in the Kamishly region of north-eastern Syria the requirement for districts receiving 350 mm or more mean annual precipitation is 50% wheat, 15% vetch, 15% lentils, and 20% melons and other crops. Even on country with less precipitation, the Syrian Agricultural Plan requires substantial use of vetch and lentils, alternating with wheat crops, to minimise or replace the traditional long fallow.

Early experiments in the Hasakeh-Kamishly region showed good performance by *Vicia dasycarpa*, *V.sativa* (Aleppo vetch type) *Pisum arvense* (field peas) and *Medicago scutellata* (Draz 1974a). However, more experimentation is needed. For example, in the Kamishly area, *Vicia dasycarpa* is favoured because of superior coldhardiness to Aleppo vetch but there have been problems because of the hard-seededness of *Vicia dasycarpa* which gives rise to unwanted volunteer vetch plants in the following wheat or lentil crop. For this and other reasons a Washington State University team (WSU 1976) has questioned the use of vetch for mixed cereal-vetch hay in northeastern Syria because of:

- (i) volunteer vetch becoming a nuisance in subsequent cereal and lentil crops;
- (ii) relatively low yields of hay, making the hay too expensive;
- (iii) poor hay-making conditions;
- (iv) high costs of transport from the area to needy livestock.

However, because of the serious shortage of conserved fodder in Syria, the WSU (1976) report needs some critical comment.

In the Kamishly area *Vicia dasycarpa* is commonly used because of its cold-hardiness but this species is known to have a substantial percentage of hard

seeds (e.g. Radwan and Al-Fakry 1975 quote 25% hard seeds) and in many places, including southern Australia, it is not recommended in cropping rotations, because of its hard-seed percentage and the consequent emergence and vigorous growth of volunteer vetch following normal seed-bed preparation and sowing of another crop. However, there are species and cultivars of vetch that are well adapted to the Kamishly region and have a zero to negligible percentage of hard seeds e.g. *Vicia narbonensis* from northern Iraq (Radwan *et al.* 1974; Radwan and Al-Fakry 1975), and *Vicia sativa* cv. Kara-elci developed at the University of Ankara, Turkey (Elci 1975). Thus the hard-seed and delayed germination problems with vetch can be minimized or avoided. Furthermore, there is scope for trying other legumes e.g. lines of Persian clover that have no hard seed. Also it is reasonable to expect that lines of *Vicia dasycarpa* without hard-seed can be identified and commercialized.

The WSU (1976) studies on the comparative economics of lentil and vetch hay production have assumed a yield of hay of 1000 kg/ha in the Kamishly region. Such very low yields of hay reflect inadequate preparation and organization of haymaking not the ecological potential of the region. Based on yields obtained in Iraq (Radwan *et al.* 1974) and in Turkey, and yields obtained in the Kamishly district (Draz 1974a) there is every reason to aim for cereal-vetch hay yields of from 5,000 - 10,000 kg/ha in the Kamishly region. There is a further point common to the whole Region: too often pasture and forage-crop legumes have been evaluated in terms of adaptation and yield without phosphatic fertilizer treatments. This undoubtedly underestimates yield and potential nitrogen fixation in most situations. Certainly, in some years some of the hay may be damaged by rain but the extent of this damage will depend on organization and the availability of side-delivery rakes (conventional or finger-wheel type) to turn the wind-rows after rain. Furthermore, if vetches without hard-seed are used then hay-making can well be delayed to minimize problems associated with wet weather as the shedding of some vetch seeds will be of no consequence.

Although the haymaking weather in the Kamishly region is certainly not unusually poor (by comparison to European, North American or southern Australian conditions) the soil preparation for reasonable haymaking is very poor but this can be greatly improved at modest cost. More attention is needed to ensure a firm, level seedbed. The use of wheeled ploughs, scarifiers and sowing implements, preferably wide implements where field size permits (Plate 1), and the greater use of harrows, chain-levelling rigs and slab levellers (Figure 2) would greatly improve the seed bed for all crops in this region. With regard to mowing of the cereal-vetch mixture it is essential to have a firm, level surface free of stones or soil clods to enable clean-cut, close-to-soil mowing irrespective of whether this is done with a sickle-bar or rotary mower. Certainly, under most conditions the sickle-bar mower will leave a more satisfactory swathe for raking and baling, but soil preparation must be good.

In addition to the role of vetches and lentils in the cereal rotation in the Kamishly area of Syria there is considerable potential for use of annual and perennial legumes and grasses as the basis of semi-permanent improved pasture suited to dairy cattle enterprises to serve that region. There is also ample scope for using vetch and other annual legumes e.g., *Medicago* spp (medics) and *Trifolium resupinatum* in other areas of Syria. However, much site-specific research is needed to adequately assess ecological adaptation and potential yields of the various pasture and forage-crop legumes and then to evaluate the potential role of these in new farming systems. There is considerable potential for greatly increasing forage crop production, including legumes like alfalfa, berseem clover and Persian clover in the various irrigation areas of Syria e.g., the Ghab Irrigation Project and especially in the Euphrates Dam Irrigation Project (see over). Further, there is great scope for increasing pasture production in the wetter hills districts of coastal western Syria.

Syrian development plans envisage c.200,000 ha of irrigated area in the Euphrates project by 1980 - including some quarter of the area sown to alfalfa and at full development the Euphrates Irrigation Project is expected to embrace 640,000 ha including 160,000 ha of alfalfa. However, current experimental evidence points to the superiority of berseem clover on some shallower soils of the Euphrates irrigation area. With adequate inputs it is realistic to assume an average annual yield of 14 t DM/ha or 15 t hay/ha from alfalfa or berseem clover on these irrigated areas. These areas could be strip grazed using simple, cheap electric fences and/or the herbage cut for hay.

Hence in Syria there is great opportunity to increase livestock feed supply by use of annual pasture and forage-crop legumes in the fallow areas of both the cereal lands and irrigated areas, by expanding the sown areas of alfalfa and berseem clover in the irrigated areas and by improving the pastures in the higher rainfall areas.

In the rainfed areas of Syria at present there are some 2.5 M ha of fallow each year. About one-third of this is in north-eastern Syria. It is not unrealistic to assume a potential average increase of 4000 kg DM/ha above current production on the wetter 1.5 M ha of fallow and an increase of 2000 kg DM/ha on a further 0.5 M ha of fallow by sowing the appropriate pasture or forage-crop legumes (with some cereals for hay): thus leaving c.0.5 M ha of fallow. This would result in an additional 7 M t DM/annum as pasture or as forage crop grazed *in situ* or as hay. Concurrently there should be increased amounts of cereal stubbles from higher-yielding crops resulting from improved soil fertility following use of legumes in the rotation also inputs of fertilizers. This should give an additional 1 M t DM.

With regard to the irrigated areas, the planned 1980 area of 50,000 ha of alfalfa on the Euphrates irrigated area should provide 700,000 t DM as grazed forage crop or as hay, and at full development 2.24 M t DM/annum (alternatively 2.4 M t hay).

Providing that feed production does not fall short of the above estimates through lack of inputs (fertilizers, insecticides, machinery and trained manpower) or through large-scale competition for land use e.g. lentils in north-eastern Syria, the potential increase thus far totals 10.24 M t per year. Further increases in feed are possible in the smaller irrigation areas and from the undoubted potential to increase pasture and forage crop productivity in coastal western Syria: these could produce another 1.76 M t. Thus there is a realistic potential to increase livestock feed supply in Syria by 12.0 M t DM/annum through improved pastures, grazed or cut leguminous forage crops or legume-based hay. This additional feed is sufficient to support 15 M ewe equivalents.

This potential feed supply is the key to the survival and development of a stable livestock industry which will enable reduced stocking and rehabilitation of the steppe rangelands of Syria. However, to achieve these goals it will involve considerable investment in seeds, fertilizers, fencing and water supplies, tillage and sowing machinery, hay-making machinery, and training at all levels. Furthermore, there will need to be good cooperation and close coordination of effort to overcome the technical and socio-economic problems of ensuring this inter-zonal and intra-zonal integration of the crop-livestock sectors in Syria. It is pleasing to note that the vital need for better crop-livestock integration and the importance of supplementary feed supply and storage to help reduce grazing pressure on the steppe has been recognized by the World Bank in financing the First Livestock Development Project in Syria. In this project the Government of Syria aims to increase and stabilize the production of, and the income from, the sheep industry in Syria through strengthening the national feed policy, the increased use of supplementary feed and the reinforcement of animal health services. The increased feed supplies that are potentially available in

the Syrian cereal zone, higher rainfall zone and irrigated areas will allow much reduced stocking on the steppe and other rangelands enabling the slow rehabilitation of these degraded areas.

## 6. Iraq

Field travel was arranged to supplement those visits made in 1973. In addition to conferring with staff of the Ministry of Agriculture and Agrarian Reform and of FAO in Baghdad the main purpose was to re-visit the Erbil, Kirkuk and Mosul areas including the College of Agriculture and Forestry at Hammam Al-Alil, Mosul, also to see the higher-rainfall areas in the Mosul-Duhok-Zakho-Turkish Border region of north-west Iraq. The various ecological zones of Iraq are described by Rafiq (1976). Northern Iraq embraces Rafiq's Kirkuk zone (200 - 600 mm precipitation) and Sungassar Zone (precipitation 600 - 1000 mm and altitude from 500 - 4000 m).

The total crop area in Iraq in 1975 was 2.28 M ha of which cereals occupied 2.02 M ha (88.6%) while legumes, with 52,000 ha, accounted for only 2.3%. However, this did represent a small increase in pulse crops over the previous 15 years.

This discussion on Iraq will be confined to the northern rainfed cropping areas where precipitation generally ranges from 250 to 600 mm annually but with most of the area receiving less than 400 mm. Soils are predominantly alkaline. An area of about 3.4 M ha of rainfed land in northern Iraq is cropped to wheat and barley on a cereal-fallow rotation (Al-Fakhry 1974; Radwan *et al.* 1974). Some 75% of Iraq's wheat and barley crop are grown in this area where also sheep husbandry is concentrated. Additionally, there are significant areas of natural grazing lands in the hilly areas of northern Iraq: these areas receive 600 - 700 mm and more in winter - spring precipitation.

At present forage-crop legumes are not grown to any extent: however, small areas of alfalfa and berseem clover are grown under irrigation also pulse crops including lentils, chickpeas and broad beans (*Vicia faba*) which are grown in rotation with cereals. Apart from recent experimental sowings, no annual pasture legumes are sown. Livestock feed resources in this cropping area are confined to grazing weedy fallows and uncropped land, stubbles and roadsides. During the dry season, livestock are maintained on straw with a little concentrate (Radwan *et al.* 1974).

In northern Iraq it has been recognized for some time that the rainfed cropping areas have serious problems associated with declining soil fertility and inadequate feed supply for livestock. These facts coupled with the uncertainties of the weather have led to very unstable farm incomes. The replacement of the fallow phase by leguminous forage crops or pasture legumes has been suggested on various occasions but several small-scale evaluation trials with introduced legumes yielded inconclusive results. Unfortunately, until recently, no attention has been given to the agronomic features and potential usefulness of the abundant flora of native legumes which are undoubtedly better adapted to local conditions than introduced legumes.

The Department of Field Crops, College of Agriculture and Forestry, University of Mosul, at Hammam Al-Alil has recently begun a comprehensive research programme related to the broad topics of increasing crop and livestock production and stabilizing land resources in northern Iraq. Of major relevance to this report is the research work related to cereal crop-legume rotation, depth of ploughing, tillage and sowing methods, optimum sowing rates for cereals and the role of phosphatic fertilizer in crop and pasture production. In 1972-73, research aimed specifically at evaluating introduced legumes - mainly medics and vetches, and the potential role of native annual medics, clovers and vetches was

initiated (Al-Fakhry 1974; Radwan *et al.* 1974; Radwan and Al-Fakhry 1975; Radwan, Al-Fakhry and Al-Hasan 1975; Al-Hasan 1976; Mohammad 1976).

Research work based at the College of Agriculture and Forestry near Mosul has shown the superiority of local lines of *Medicago polymorpha* and *Medicago orbicularis* in terms of herbage yield, pod yield, nodulation, hard seed percentage and palatability to sheep when compared with other local and introduced medics. Al-Hasan (1976) pointed out that *Medicago polymorpha* var. *vulgaris* followed by *M. orbicularis*, *M. rigidula* var. *rigidula* and *M. minima* constituted 85% of all medics whereas *M. polymorpha* vars. *brevispina* and *polymorpha*, *M. rigidula* vars. *cinerascens* and *agrestis*, *M. constricta*, *M. rotata*, *M. neana* and *M. radiata* appear to be minor forms as they make up only 15% of the medic population in the sampled area comprising plains and foothills of northern Iraq. Of the fourteen ecotypes representing eight species of the genus *Medicago* that were collected it is hoped to release those of most promise as commercial cultivars.

In other research *Vicia narbonneensis* (narbonne vetch) and *Vicia dasycarpa* (Lana woolly-pod vetch) proved superior on the basis of herbage production to seven other cultivated and wild species of vetch. It was also found that these two species gave better performance when mixed with barley and oats, respectively. However, neither of these vetches were good competitors against weeds and it was found to be important not to graze below 8 - 10 cm height to ensure proper regrowth and pod formation. It should be emphasized that narbonne vetch, a native of northern Iraq, with a yield of 4532 kg DM/ha significantly out-yielded all other vetches in the experiments. Furthermore, common wild vetch *Vicia sativa* from northern Iraq performed quite well whereas bard vetch (*V. monantha*) and chickling vetch (*Lathyrus sativus*) from Iraq were much inferior in production (Radwan and Al-Fakhry 1975).

This research shows clearly that there are well adapted native medics and vetches in northern Iraq which could be put to immediate use to replace bare fallow in that region. However, the research programme needs to continue especially with regard to hard seed production and persistence of hard-seededness. In a two-course rotation it is important that there is no significant percentage of permeable seeds available for germination after seed bed preparation or after sowing and emergence of the cereal crop. This is unlikely to be a problem with narbonne vetch which apparently has a low percentage of hard seeds (Radwan *et al.* 1974). The problems resulting from germination of unwanted vetch in both cereal and lentil crops in the Kamishly region of north-eastern Syria were mentioned in the previous section.

In addition to the promising lines of annual species of *Medicago* and *Vicia* mentioned above, other species with possible potential as pasture or forage-crop legumes are widespread in northern Iraq particularly in higher-rainfall areas that are not cropped, or cropped infrequently. Such areas occur around Duhok (Alt. c.500 m; Precipitation c.600 mm; Mean min. winter temperature c.0°C) and between Duhok and Zakho (Alt. c.600 m precipitation c.600 - 700 mm) and along the Turkish border.

Radwan *et al.* (1974) examined the seed characteristics, palatability to sheep and frequency of occurrence in northern Iraq of the following legumes (Table 12) and concluded that *Scorpiurus sulcata*, *Onobrychis crista - galli* and *Vicia sativa* had potential for sowing onto fallow fields. However, it is clear that more detailed research is needed on the complex soil-plant-animal inter-relationships determining long-term success of these legumes. In addition to the legume species listed in Table 12 *Astragalus* spp. *Melilotus indica* and *Prosopis fraxta*, *Trifolium incarnatum*, *Trifolium stellatum* and others are common in northern Iraq.

With regard to the palatability assessment (Table 12) the data should be

treated with considerable reservation because of inherent bias caused by the prior training and experience of the sheep with the particular species and the difficulty of making equivalent-quality hays from the various species. However, the data do indicate the importance of including palatability as one of the checks in screening potential new pasture and forage-crop species.

TABLE 12

HARD SEED PERCENTAGE AND PALATABILITY ESTIMATES FOR NATIVE ANNUAL LEGUMES FROM NORTHERN IRAQ

Legume	Hard Seed (%)	Palatability (Percent Eaten)	
		Green	Hay
<i>Coronilla scorpioides</i> (L.) Kock	85	68.5	0.0
<i>Hippocrepis unisiliquosa</i> L.	79	91.5	7.2
<i>Hymenocarpus circinnatus</i> (L.) Savi	- <sup>+</sup>	24.0	6.4
<i>Lathyrus gorgini</i>	-	71.2	37.5
<i>Lathyrus sativus</i> L.	26	72.0	26.5
<i>Lathyrus</i> spp.	-	90.0	40.8
<i>Medicago minima</i> (L.) Desr. <sup>++</sup>	98	-	-
<i>Medicago orbicularis</i> Bartal <sup>++</sup>	94	-	-
<i>Medicago polymorpha</i> L.	91	87.5	42.4
<i>Medicago rigidula</i> (L.) Desr.	74	-	-
<i>Onobrychis crista-galli</i> Lam.	6	81.5	100.0
<i>Scorpiurus sulcata</i> L.	78	76.0	67.5
<i>Trigonella coelesyriaca</i> Boiss.	91	92	6.2
<i>Trigonella</i> spp.	96	85.5	83.3
<i>Trifolium campestre</i> Schreb.	94	69.0	76.1
<i>Trifolium lappaceum</i> L.	92	-	-
<i>Vicia angustifolia</i>	-	74.1	12.5
<i>Vicia calcarata</i> Desf.	86	78.0	72.7
<i>Vicia narbonensis</i> L.	0	95.0	24.4
<i>Vicia sativa</i> L.	40	91.5	10.3

Source: Radwan *et al.* (1974). <sup>+</sup> - = Not determined. <sup>++</sup> Not according to Heyn (1963).

In addition to the annual species of *Medicago*, *Melilotus*, *Trifolium*, *Lathyrus* and *Vicia* that have become naturalized over wide areas of southern Australia it is relevant to note that the native grass flora (both annual and perennial) of northern Iraq contains many species that are successful sown or volunteer grasses in southern Australia, e.g. *Lolium rigidum*, *Phalaris tuberosa* (syn *P. aquatica*), *Phalaris minor*, *Hordeum murinum*, *Hordeum leporinum*, *Bromus* spp. *Avena* spp. Likewise, many weeds are common to northern Iraq and South Australia, e.g. *Convolvulus arvensis*, *Cynodon dactylon*, *Papaver rhoeas*. Although local ecotypes of annual *Medicago* species perform better in northern Iraq than do commercial cultivars of Australian medics this is to be expected in view of the relatively colder winters in northern Iraq, where mean minimum temperatures are often 0°C or less in the coldest month, whereas the mean minimum winter temperatures in the recognized medic areas of southern Australia are generally >2°C (Carter 1974b, 1975a; Appendix A, Table 3).

It is quite obvious that northern Iraq has a potential to use annual pasture legumes (e.g. *Medicago* spp.) and/or forage-crop legumes (e.g. *Vicia* spp.) in rotation with cereals. Some 1.5 M ha of land is left as fallow each year in northern Iraq. On the assumption of improved inputs of superphosphate it is not unreasonable to have a production goal of increasing the mean pasture/forage-crop production by 4000 kg DM/ha i.e., giving a total improvement in pasture/forage production in the rainfed cropping zone of 6.0 M t DM/year. Concurrently there should be an increased production of edible crop residues totalling 0.8 M t DM/year. This total of 6.8 M t is sufficient to support 8.5 M ewe equivalents.

The development of some of the permanent grazing areas in the foothill and hill country by topdressing with superphosphate to encourage greater pasture production, and reduced runoff and erosion, represents a further potential for significant increases in carrying capacity. This grazing region could well supply an additional 2.0 M t DM while increased production of forage crops and crop residues in irrigated areas could supply a further 0.8 M t DM. Thus there is a potential to grow an additional 9.6 M t DM of livestock feed as pasture and forage crops each year. This is sufficient to support 12.0 M ewe equivalents. Even if only half this potential is achieved in the foreseeable future, this would enable greatly reduced grazing pressure on the steppe rangelands and a much more productive, profitable and stable livestock industry. Concurrently, a well-established cereal-legume rotation should greatly improve cereal production in the rainfed areas of Iraq.

An important part of the University of Mosul is the Applied Agricultural Research Centre (AARC) organized within the College of Agriculture and Forestry at Hammam Al-Alil. The AARC, which is a useful model for the Region, was formed in 1973 to help find solutions to the important and urgent problems facing the agricultural industries in Iraq. The AARC has a governing Council for Applied Agricultural Research under the Chairmanship of the President of the University of Mosul and this Council includes members of the University (especially heads of Departments in the College of Agriculture and Forestry), the full-time Director of the AARC and representatives from the Ministry of Agriculture and Agrarian Reform.

The objectives (in brief) of the Applied Agricultural Research Centre are:

- (i) to activate, sponsor and support applied agricultural research in different fields of agriculture, animal production and forestry with a view to finding solutions to problems facing agricultural development in Iraq, and to raise the standard of agricultural production in the country;
- (ii) to locate specific agricultural problems existing in the country and allot priorities to these problems for tackling in order of their urgency;
- (iii) to encourage the teaching staff working in different agricultural specializations in the College to formulate applied research projects;
- (iv) to arrange and supervise graduate studies in all fields of agriculture;
- (v) to guide new researchers and research assistants to conduct quality research;
- (vi) to publish completed research investigations and arrange transfer of findings;
- (vii) to afford assistance to other sister departments engaged in development;
- (viii) to review progress of agricultural research activities of the College;
- (ix) to establish contacts with other agricultural research centres in Iraq as well as in Arab and foreign countries for cooperation in research;
- (x) to arrange training of the employees of Applied Agricultural Research Centre in foreign countries in different fields of agriculture including research;
- (xi) to manage and provide research facilities available within the country and from outside to teaching staff of the College and sister organizations.

The technical expertise for the AARC is drawn mainly from the ten Departments at the College, viz: (i) Department of Agricultural Economics and Extension; (ii) Department of Agricultural Education; (iii) Department of Animal Production; (iv) Department of Field Crops; (v) Department of Food Technology; (vi) Department of Forestry; (vii) Department of Horticulture; (viii) Department of Plant Protection; (ix) Department of Soil Science; and (x) Division of Farm Mechanization. As an indication of the size of the College of Agriculture and Forestry, the academic staff in 1976-77 numbered 46 Iraqis, 38 other Arab Nationals and 9 Foreigners comprising 15 Professors, 32 Assistant Professors, 29 Lecturers and 17 Assistant Lecturers of whom 77 had Ph.D. and 16 M.Sc. degrees: undergraduate students comprised 1295 males and 219 females and postgraduate students numbered 52. From these figures and from the general air of confidence and enthusiasm at the College of Agriculture and Forestry at Hammam Al-Alil it is clear that this College has the potential to become one of the leading agricultural research and training centres in the Region.

PLATE 5IRAQ

Left: Mosul district, Iraq. For small farms there is an urgent need for suitably adapted grain legumes, alternatively leguminous forage crops, to use in rotation with the cereal crop.

Right: Duhok district, Iraq. On large holdings, or amalgamated farms, there is scope for realistic use of self-regenerating pasture legumes (e.g. annual medics) or regularly-sown forage crop legumes (e.g. vetches) for grazing and/or hay.

(Photographs: Iraq, May 1977).

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SYRIAN A.R. AND JORDAN

Left: Drought in the marginal areas of Syria generally gives some financial return in the form of agistment of sheep on the failed cereal crops.

Right: With the critical shortage of arable land in Jordan, cropping is extending onto marginal hill lands and semi-arid areas.

(Photographs: Jordan, April 1977; Syria, May 1977).

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SYRIAN ARAB REPUBLIC

Left: Lambs awaiting sale in the market place at Hasakeh.

Right: Sheep moving in to graze the stubbles of irrigated crops in the Ghab district: a good example of interzonal complementarity.

(Photographs: Syria, May 1977).

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SYRIAN ARAB REPUBLIC

At the El Kreim Centre for Sheep Improvement, Salamiyeh, Syria, the Syrian Government and ACSAD have an active programme of selection and breeding of Awassi sheep for distribution to Arab League countries.

Left: Awassi ewes hitched together for milking.

Right: Shearing Awassi rams.

(Photographs: Syria, April 1973 (left) and May 1977 (right)).



## 7. Turkey

The field visiting in Turkey was confined to the Ankara region of Central Anatolia (850 - 1000 m altitude) and the Erzurum region of Eastern Anatolia (1800 - 3000 m altitude). These regions are representative of the relatively dry, cold, wheat-growing areas of Central Anatolia and the higher, colder, wetter eastern fringes of the wheat belt merging into the pasture-livestock areas based on the rangelands and mountain meadows of Eastern Anatolia. Both regions are representative of extensive and very important farming and grazing areas in Turkey.

Turkey, with 17.3 M ha of crop in 1975, had 13.6 M ha (78.4%) of cereals and only 0.60 M ha of legumes (3.4%) of which 0.35 M ha (2.0%) were forage-crop legumes. While Turkey has by far the largest crop area of any country in the Region, it also uses more inputs in the way of fertilizers, herbicides, etc. and this is reflected in higher yields. In fact, in recent years Turkey has been the seventh largest wheat producer in the world. During the period 1971-75, Turkey's wheat production averaged 12 M t at an average of 1400 kg/ha and in 1976, 16.5 M t of wheat were produced.

The dramatic increase in wheat production in Turkey has resulted from an excellent cooperative programme involving staff of the Turkish Ministry of Agriculture, USAID, Oregon State University, The Rockefeller Foundation and CIMMYT. It has been a classic example of the advances made possible by a dedicated, multidisciplinary group working with a single crop commodity - involving attention to wheat breeding, plant pathology, agronomy, cereal technology, economics and extension. However, the Turkish Wheat Research and Training Project has been well-supported by Government and the bilateral and multilateral agencies and in 1977 there were 67 Ministry staff working on the wheat programme including 29 wheat breeders, 7 plant pathologists, 14 agronomists and four subject-matter extension specialists (Demirlicakmak 1970; Breth 1977; Wright 1977).

The success of the wheat project will hopefully provide a model for other winter/spring wheat-producing areas of the Region. However, while not detracting from this success with wheat production, it must be recognized that during this period of rapid improvement of the Turkish wheat industry there has been a concurrent neglect of the pasture/rangeland-livestock sector in Turkey and this requires urgent attention with similar types of financial incentives as used to encourage wheat production. More livestock feed is needed urgently: yet the grazing pressure on the rangelands must be relieved to arrest further serious degradation of productivity, loss of ground cover and consequent soil erosion. Now that Turkey is self-sufficient with regard to wheat (current annual need is c. 11 M t), hopefully more attention will focus on the crucial livestock problem arising from the diminishing area and deteriorating productivity of the rangelands. Unfortunately, the expansion of the Turkish wheat crop, and other crop areas, has been at the expense of the best rangelands.

Although the area and productivity per unit area of the rangelands are both declining, livestock numbers are increasing. Livestock grazing pressure on the rangelands more than doubled during the 25 years from 1940 to 1965 - from 2.16 ha/AU<sup>+</sup> in 1940 to 1.04 ha/AU in 1965. In Central Anatolia the climax vegetation including *Agropyron* spp., *Bromus erectus*, *Andropogon* sp., *Dactylis* sp., *Phleum* sp., *Medicago* spp. and *Onobrychis* spp. has largely disappeared under the influence of cropping and heavy grazing and the climax species replaced by *Artemisia fragrans* and *Thymus squarrosus* as the dominants on large areas. Although improvement of degraded rangelands is possible and is economic (Tosun *et al.* 1977) extensive rangeland restoration is a very expensive long-term programme and will be impossible without complete exclusion of livestock from the most-damaged areas - in some cases for several years.

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1 Animal Unit (AU) is assumed to have a bodyweight of 250 kg.

While most of Turkey's rangelands are common lands, traditional claims to grazing rights on particular lands are recognized. The problem is to properly identify those with legitimate claims to grazing rights and to issue grazing permits for a specified number and kind of animal for a given period : but this is essential if the decline in rangelands is to be arrested. At present there appear to be insufficient legal machinery and procedures to punish those who do not adhere to the rules. Draft regulations concerning grazing regulations have been discussed for 20 years but apparently no finality has been reached : yet there is ample evidence that there were well-developed rules concerning grazing in the Region since Biblical times. It would appear that the ancient Hittites had rules concerning permissible numbers of livestock per unit area (Gurney 1952 p.81)+.

A major constraint to research and development in the pasture/rangeland-livestock sector is the meagre support with staff and resources by comparison to the wheat project. There is an urgent need for surveys to define the productivity of existing grazing areas and the potential carrying capacity given various levels of inputs. However, the few pasture/rangeland workers in Turkey have achieved a great deal. Substantial progress has been made in the collection, evaluation, selection and breeding of both regional ecotypes and introduced species of both pasture and forage-crop legumes and other species.

The Grassland and Animal Husbandry Research Institute, Ministry of Agriculture, at Ankara has been evaluating *inter alia* the following Turkish ecotypes of legumes in addition to many local and introduced grasses: *Astragalus* sp., *Hedysarum* sp., *Lathyrus sativus*, *Medicago lupulina* (black medic) *Medicago sativa*, *Onobrychis* sp., *Vicia amphicarpa* (subterranean vetch) *V. pannonica* (Hungarian vetch), *V. villosa* (hairy vetch) and *Trigonella foenum-graecum* (fenugreek). Other work involves studies on the optimum sowing time, rate of sowing and row spacing of *Poterium sanguisorba* (sheep's burnet), also selection of better lines of *Medicago sativa* (Kayseri alfalfa), *Onobrychis sativa* *Poterium sanguisorba* and increasing seed supplies of these species. The legume/cereal rotation work begun by Bilensoy (1970) is also being continued (Alinoglu 1976, 1977; Munzur 1976). This Institute is responsible for the regional testing of all potential pasture and rangeland cultivars but the work is greatly constrained through lack of staff and equipment.

The Department of Forage Crops and Pastures in the Faculty of Agriculture, University of Ankara has had an active interest in the collection, evaluation, cytogenetics and modification by breeding of Turkish ecotypes of legumes and grasses as well as the broader issues of the role of leguminous forage crops in cereal rotations and range management in meeting the feed needs of Turkish livestock (e.g., Elci 1975, 1976; Bakir 1976). Genetic research on the annual *Medicago* spp. is being continued by Erac (personal communication) following his earlier work with Lesins (e.g. Lesins and Erac 1968) while cytogenetic studies by Elci include those on red clover (*Trifolium pratense*), perennial ryegrass (*Lolium perenne*) and *Secale montanum*. Professor Elci has also selected a blackseeded, cold-tolerant productive line of *Vicia sativa* (cv. Kara-elci) with no hard seeds. This is ideally suited to rotation with cotton and other crops (Elci 1975).

One very important area of work concerns the collection and evaluation of local Turkish ecotypes of grasses and legumes that are salt tolerant. Elci (1976) has selected the following salt tolerant plants for use in Turkey's problem areas: *Trifolium fragiferum*, *Agropyron cristatum*, *Agropyron junceum mediterraneum*, *Medicago littoralis*, *Medicago marina*, *Medicago sativa*, *Festuca arundinaceae*, *Lolium perenne* (Prostrate type), *Lotus corniculatus* var. *corniculatus* (Erect type) and *Lotus corniculatus* var. *tenuifolius* (Prostrate type).

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+ Acknowledgement is made to Doc. Dr. Vecdet Erkun of the Turkish Ministry of Agriculture for drawing attention to this reference.

Furthermore, *Puccinellia* sp. has been used under extremely saline conditions. This selection and evaluation work is of great importance to the whole Region and also other saline areas with relevant climates around the world.

Eastern Anatolia, as typified by the Erzurum region, is mainly a pasture-livestock environment although animals must be housed in winter. The Ataturk University and Ministry of Agriculture have a most impressive range of pasture and forage crop research activities in the Erzurum region. Pasture and forage-crop legume selection, breeding and evaluation includes the following species: *Medicago sativa*, *Onobrychis sativa*, *Trifolium ambiguum* (Caucasian clover) and *Trifolium pratense*. It is pleasing to record the excellent cooperation within and between the University Departments of Crop Science, Soils and Animal Science and also between the University Faculty of Agriculture and regional representatives of the Ministry of Agriculture at Erzurum. Such cooperation is an essential feature of effective regional research.

Many of the upland grazing areas (2000 - 3000 m altitude) in the Erzurum region are in very good condition with a rich flora including an abundance of native pasture legumes. Research workers in the Department of Crop Science at Ataturk University have studied the upland flora and listed 439 species from 218 genera. This includes 33 genera and 63 species of composites, 30 genera and 58 species of grasses and 12 genera and 41 species of legumes (Table 13). The region includes some excellent meadows with yielding capacity commonly from 4000 - 8000 kg DM/ha. Some meadows with an apparent potential yield up to 10000 - 12000 kg DM/ha occurred in very favoured micro-environments but these may have received some fertilizer. However, on the well-drained and rocky slopes the native rangelands are quite poor and unproductive though these are capable of improvement which can give economic returns (Tosun *et al.* 1977).

TABLE 13

## NATIVE LEGUMES IN THE ERZURUM REGION OF TURKEY

<i>Astragalus atrocarpus</i>	<i>Medicago polymorpha</i>
" <i>candiculosus</i>	" <i>sativa</i>
" <i>cinereus</i>	" <i>varia</i>
" <i>coarctatus</i>	<i>Melilotus officinalis</i>
" <i>eriocephalus</i>	<i>Onobrychis cornuta</i>
" <i>globosus</i>	" <i>hajastana</i>
" <i>lappurus</i>	<i>Ononis spinosa</i>
" <i>lineatus</i>	<i>Trifolium alpestre</i>
" <i>mukusiensis</i>	" <i>ambiguum</i>
" <i>odoratus</i>	" <i>canescens</i>
" <i>ornithopoides</i>	" <i>caucasicum</i>
" <i>ponticus</i>	" <i>fragiferum</i>
<i>Cicer anatolica</i>	" <i>hybridum</i>
<i>Coronilla orientalis</i>	" <i>pratense</i>
" <i>varia</i>	" <i>procumbens</i>
<i>Lathyrus pratensis</i>	" <i>repens</i>
" <i>tuberosus</i>	" <i>trichocephalum</i>
<i>Lotus corniculatus</i>	<i>Trigonella aurentiaca</i>
<i>Medicago falcata</i>	" <i>fischeriana</i>
" <i>lupulina</i>	<i>Vicia villosa</i>
" <i>papillosa</i>	

Source: Department of Crop Science, University of Erzurum, Turkey.

The technical and economic problems of rangeland improvement in Turkey are complicated by the need for relatively long-term improvement projects. Bakir and Acikgoz (1976) are pessimistic about the success of significantly improving degraded rangelands by resting because of lack of basal cover which is frequently

less than 10% giving rise to accelerating problems of erosion. Furthermore, although some rangeland rehabilitation has occurred through sowing of *Bromus inermis* (smooth brome grass), *Agropyron cristatum* (crested wheat grass), *Agropyron intermedium* (intermediate wheat grass), *Festuca arundinacea* (reed fescue), *Medicago sativa* and *Onobrychis sativa* in Turkey, this has been generally too expensive for broadscale application. While fertilizer application usually increases production of dryland rangelands it is not economic in many situations: however, fertilizer application to wet meadows such as found in Eastern Anatolia appears to be economical. Also some wet meadows give tremendous yield response to drainage plus fertilizer application (Bakir and Acikgoz 1976).

Despite the twenty five years of active research on pastures, forage crops and rangeland management in Turkey the livestock feed deficit is increasing and the rangelands continue to deteriorate. Whereas in 1938 there were estimated to be 41.07 M ha of common grazing lands this had declined to 21.74 M ha by 1975 (21.10 M ha of rangeland and 0.64 M ha of meadow) which provided sufficient feed for only 12 M animal units yet there were then 27.5 M animal units in Turkey (Alinoglu, Akyuz and Aldemir 1976; Bakir and Acikgoz 1976; Sahin and Ozugur 1976). In 1975, despite this feed deficit, only about 440,000 ha of forage crops including 350,000 ha of legumes was sown. The most important species of sown legumes were *Vicia sativa* - Common vetch and also cv. Kara-elci (112,000 ha); *Medicago sativa* (110,000 ha) and *Onobrychis sativa* (51,000 ha).

The best prospects for increasing livestock feed are by encouraging better crop-livestock integration and especially by using for the production of forage crops much of the current 9 M ha that is left as fallow each year. Herein lies a major dilemma because there has been widespread encouragement of clean fallowing for water conservation and weed control as part of the package for ensuring good wheat yields (e.g. Gerek 1970; Gifford 1970; Guneyli 1970; Yesilsoy 1970). However, there is no doubt that in Central Anatolia and probably in many other areas the fallows are not clean-cultivated and farmers compromise between early ploughing to achieve better weed control and seed-bed preparation and later ploughing to allow greater production of herbage hence more grazing on weedy fallow. Certainly the farmers recognize the benefits and value in terms of securing extra feed by ploughing later and this is readily translatable into money terms. It is quite realistic to grow an extra 1000 - 2000 kg DM of feed per hectare by delaying ploughing for three to four weeks. Providing that the weedy volunteer growth on the fallow areas is green and readily eaten, but not poisonous, the net nutritive value is not going to differ greatly from sown pasture or forage crop and will generally be superior in quality to purchased hay which is frequently sold for US\$100 - \$150/t. With regard to feed value, it is interesting to note that *Reseda lutea*, a common component of weedy fallows in Central Anatolia, has been found to be comparable to alfalfa in chemical composition and is recommended for rangeland sowing in Iran (Moghaddam 1977).

In the recommendations for wheat growing in Turkey it would appear that inadequate account has been taken of the livestock feed value of the volunteer growth on fallow land. An example of common species on fallow is given in Appendix A, Table 7. Usually, available feed on the fallows must be valued in terms of potential savings of purchased feed. Thus, the difference between early and late ploughing of the fallow area in preparation of the seedbed for the next crop could amount to US\$100 - 200 or more per hectare at prevailing prices of hay. Clearly, the value of this feed on the fallow must be assessed in terms of the whole farming system and may well help to explain why some farmers have been reluctant to follow a total package of recommendations for wheat growing in Turkey as reported by Mann (1977a,b) where this vital component of livestock feed is neglected in the wheat-growing recommendations (Hepworth and Tezel 1976).

Once there is widespread recognition of the necessity and advantages of using the fallows to produce much-needed livestock feed in Turkey, then by deliberate sowing of pasture and forage-crop legumes it is possible to greatly

increase feed supply and at the same time ensure some restoration and/or improvement in soil nitrogen levels to enhance cereal production. In fact, alfalfa, sainfoin and vetch have been successfully used in rotation with cereals for several years but the practice is not widespread (Bilensoy 1970; Elci 1975, 1976; Alinoglu, Akyuz and Aldemir 1976; Bakir 1976; Bakir and Acikgoz 1976; Sahin and Ozugur 1976; Alinoglu 1977). Instead of using legumes in the rotation to increase feed supply and help the nitrogen economy of the soils there has been a disproportionate emphasis on using expensive, artificial nitrogenous fertilizer, much of which has been imported.

The rotation work of Bilensoy (1970) and Bakir (1976) has shown clearly that total wheat production and livestock feed supply can be increased concurrently. Certainly there are well-adapted annual vetches (e.g. *Vicia sativa* cv. Kara-elci and *V. narbonensis*) and *Pisum arvense* that have no hard seed problems for those who wish to adhere to the traditional cereal crop in alternate years. Rotation experiments in Central Anatolia using alfalfa, sainfoin and fallow treatments showed clearly that winter wheat production can be increased by substituting these legumes for fallow and, because of the increase in livestock feed, income is greatly increased (Bilensoy 1970). Other experiments using annual legumes (*Vicia sativa*, *Vicia narbonensis* and *Pisum arvense*) in pure stands or mixed with oats have shown that wheat yields increased and hay yields of 2 to 3 t/ha were obtained (Alinoglu 1977).

Bakir (1976) has reported on another series of experiments in the Western Transition Zone of Turkey where the annual legumes - fenugreek (*Trigonella foenum-graecum*), Hungarian vetch (*Vicia pannonica*), hairy vetch (*Vicia villosa*), black medic (*Medicago lupulina*), common vetch (*Vicia sativa*) and field peas (*Pisum arvense*) were sown in mixture with oats (*Avena sativa*), barley (*Hordeum vulgare*) and rye (*Secale cereale*) as forage crops in the fallow year in rotation with wheat and barley. The results showed clearly that it was possible to grow small-grain and annual-legume forage crop mixtures without reducing the yield of the following wheat or barley-grain crop. In fact, in three separate locations the most promising small-grain/legume mixture was rye plus field peas which averaged 2327 kg DM/ha and was considered to increase net income by US\$30 - 50/ha over and above the traditional wheat-fallow system. However, Hungarian vetch, hairy vetch and common vetch, performed almost as well as field peas. There is a clear need for such rotation experiments to continue to more-clearly define ideal small grain-legume sowing mixtures because sowing rate of cereal and legume may have a very significant effect on yield and botanical composition and consequent value as hay of the various forage crops. Also it is important to establish whether the superiority of rye over barley and especially oats was related to winter hardiness, plant nutrition, or possibly the control of cereal root pathogens. Clearly there is also a need to establish a range of optional inputs of fertilizers to produce these forage crops.

It is difficult to assess the total potential impact in Turkey of making widespread use of the fallow for the sowing of leguminous forage crops without more data because at least in many cases there is already useful weedy growth on the fallows. However, it is not unreasonable to postulate a potential mean increase of 2500 kg DM/ha from suitably adapted, phosphate-fertilized, forage-crop legumes or mixtures on say 8 M ha of the existing 9 M ha of fallow area. This should provide an additional 20 M t DM. There is less scope for improving the yield of useful crop residues in Turkey because existing use of fertilizers is widespread. However, there is scope for a potential increase of c.4 M t DM from this source. Thus in the cereal zone the potential increase is 24 M t DM, which is sufficient for 30 million ewe equivalents or approximately 6 million AU.

The more efficient use of irrigation water could enable much more feed as irrigated forage crops to be grown in Turkey and the fertilization of natural meadow land and some of the better rangelands especially of Eastern Anatolia could greatly assist in supplying the needs of Turkey's flocks and herds.

These sources could well provide an additional 4 M t DM, given the necessary financial incentive and inputs. Certainly some drastic livestock culling is needed but the potential exists to support a total livestock load similar to that present today if the various actions to increase feed supply are taken. Of course, the major impact of these options would be to greatly reduce the grazing pressure on the rangelands which would expedite recovery of these areas and provide the potential for future expansion of the livestock industry.

Not only would these forage-crop legumes provide urgently-needed feed but, if properly nodulated, would certainly fix much-needed nitrogen. On the assumption that the mean net increment of soil nitrogen (Carter 1974b, 1975a; Nutman 1976) is 60 kg/ha on this area of 8 million hectares of sown legume, this is equivalent to 480,000 metric tons of nitrogen which is similar to or greater than the annual quantity used in Turkey in recent years. Not only is there tremendous potential advantage from sowing the fallow lands to legumes in terms of livestock feed supply and nitrogen fixation, but also these legumes should effect real improvement in soil structure and infiltration (Bilensoy 1970) as well as greatly reducing the common weed problems and some diseases of cereals. Turkey is fortunate in having undertaken much of the necessary research relating to the role of legumes in the cereal rotation : as with wheat production, Turkey ranks seventh in the world with respect to livestock and what is needed now is the same kind of determination by Government and its various departments to ensure that the pasture/rangeland-livestock sector is improved in the same way as was the wheat industry.

#### 8. Iran

Field visiting in Iran was designed to supplement previous visits made as a member of the TAC Mission in 1973 (Skilbeck *et al.* 1973). The 1977 field visits embraced major crop and livestock-producing areas including the Central Plateau Zone, the Caspian Coast Zone, the Continental Mediterranean Zone and the Cold Temperate Mediterranean Zone, as given by Rafiq (1976). Visits involved the following road travel:

- (i) Tehran-Damavand-Amol-Babol-Sari-Behshahr-Kordkoy-Gorgan-Shah Mazraee and returning to Tehran via Sari-Nowshahr-Kelardasht-Karaj;
- (ii) Tehran-Qum-Arak-Borujerd-Khorramabad-Malavi-Shahabad-Kermanshah-Sanandaj-Miyandoab-Maragheh-Tabriz-Marand-Maku-Turkish Border at Bazargan then returning to Tehran via Tabriz-Miyaneh-Zanjan-Karaj;
- (iii) Tehran-Karaj-Heyderabad-Teheran; and
- (iv) Tehran-Dizin-Sirachala-Karaj-Tehran.

These field visits were complemented by discussions with officers of the Ministry of Agriculture and Natural Resources, the University of Tehran and the Food and Agriculture Organization in Tehran and Karaj (Appendix B).

Of the total crop area of 8.85 M ha in Iran in 1975, cereal crops accounted for 7.59 M ha (85.8%) while leguminous crops (mostly pulses) accounted for only 228,000 ha (2.6%). In fact, leguminous crop area declined during the period from 1961-65 to 1975 whereas cereals increased markedly (Table 4). From the field visiting and discussions it was obvious that, though there had been substantial progress in production of various crops, there were still grave problems in the pasture/rangeland-livestock sector through overgrazing i.e., by too many livestock for the diminishing area and productivity of rangelands and other grazing areas with consequent low productivity per head from grazing livestock and disastrous denudation and resultant soil erosion problems.

The estimated area of rangelands in Iran varies from 71 to 106 M ha, depending on the method of classification. About 75% of these rangelands are in poor to very poor condition with a current carrying capacity of some 11 M sheep units but with a total livestock load at least four times greater than it should

be to offer any real opportunity for rehabilitation of the rangelands.

In a forthright review of the requirements for the development of the Iranian livestock sector, a USDA Agricultural Development Team have commented on the institutional and administrative rigidities constraining the livestock industries and have emphasized the need for better coordination of effort both between and within Ministries to achieve proper control of grazing of the rangelands, and a rapid reduction in present livestock numbers (USDA 1975). Though marked improvement in the sheep flock by selection and cross breeding is possible (Foote 1975), this type of research and development is wasted without concurrent improvement in the feed supply for sheep - and other livestock (Mason 1967; Demirören 1972; Faulkner 1972; Skilbeck *et al.* 1973). The precarious existence of the Iranian rangelands is well-summarized in the USDA team report which states: "Rangelands of Iran probably were stocked at an overall proper rate in the early 1930's or as late as the 1950's although there were areas of overgrazing particularly in the vicinity of villages. Since that time livestock numbers (expressed as sheep equivalents) have at least doubled in the country. Ranges have deteriorated seriously during the past one or two decades and by 1970 were estimated to be stocked at approximately four times proper use level. General range deterioration is accelerating, and if unchecked will destroy the range livestock industry of Iran in a few years". (USDA 1975, Vol.2, p.93).

Where livestock have been excluded from rangelands, recovery of the stands of native species is possible, but generally slow. This process can be accelerated by sowing appropriate range species (e.g. Mehdizadeh 1973; Peymani and Tarifi 1972, 1975; Foroughian, Tizray and Mesdaghi 1977) but this is expensive. However, the rehabilitation of the rangelands must be viewed not only in terms of livestock feed but also in terms of watershed management - involving the prevention of soil erosion and siltation of reservoirs and irrigation works. Although the rangelands of Iran, in common with the rest of the Region, are in very poor condition over huge areas, active measures have been instituted to control grazing or preclude grazing. This has led to a dramatic improvement in range condition. In particular, the restriction of grazing on reservoir catchment areas (e.g. Karaj Dam catchment) is most beneficial in limiting the reservoir intake of soil and other contaminants.

Iranian grazing lands, both National Rangelands and pasture and range allocated to villages at the time of land reform, are to a large extent used as "commons" - i.e., used in common by all people. This has led to overuse. Though a grazing permit system has been in operation for some years in Iran, according to the Chief of the Forest and Range Organization (Goodarz Shadaee) there have been inevitable conflicts as to who will be issued permits and for how many animals. Initially these problems were solved on the basis of historical land-use patterns and ownership of adjacent lands, and the grazing licences were aimed at balancing livestock numbers with carrying capacity. However, livestock numbers as specified in the licence have been inadequately policed: therefore, it has been difficult to enforce the law which was enacted in 1962. The present policy is to insist on a range management plan at Rials 50/ha (= U.S.\$0.71/ha) as a prerequisite for a licence and this has "led to big queues for range management plans and licences" (Shaidee, personal communication). Certainly, there needs to be strict control of numbers of grazing animals on the rangelands: one possible method to ensure rapid offtake of young animals and non-productive older animals could be to levy a tax on the numbers of adult sheep, goats and cattle. Such a tax should be independent of the fees associated with obtaining a grazing licence.

Both the Forest and Range Research Institute (FRRI) and the Forest and Range Organization (FRO) have been involved in evaluation of Iranian species and ecotypes also imported species and ecotypes of pasture and rangeland plants in the various agro-ecological zones, and both organizations are involved in studies

on sand dune fixation and watershed management research and practices. However, the FRRI has prime responsibility for collection and evaluation of local ecotypes and evaluation of imported species. Appendix A, Table 8 gives a list of Iranian ecotypes that are being evaluated at present. The following species which have been used in rangeland rehabilitation in cold, arid, and more temperate areas of Iran give an indication of the climatic and general ecological span of the rangelands and other grazing areas: *Agropyron desertorum*, *Agropyron elongatum*, *Atriplex canescens*, *Atriplex halymus*, *Atriplex nummularia*, *Dactylis glomerata*, *Festuca arundinacea*, *Lolium perenne*, *Lotus corniculatus*, *Medicago sativa*, *Onobrychis sativa*, *Trifolium pratense* and *Trifolium repens*.

One legume species that appears to have considerable potential for watershed management purposes at high altitudes ( $\geq 3000$  m) is the native Iranian *Trifolium radicosum*, seen in the Dizin district. This rhizomatous, and stoloniferous, perennial clover has the prostrate habit ideal for soil stabilization on the high mountains and probably has a greater degree of cold tolerance than *Trifolium ambiguum* (Caucasian clover) which is widely used at high altitudes (Bryant 1974). It is strongly recommended that *Trifolium radicosum* be studied with a view to determining environmental constraints to growth and seed production, and assessing the potential for seed production at lower altitudes. If seed of *T. radicosum* can be produced then it should prove a most valuable species for aerial sowing on some of the high mountain watershed areas in Iran and elsewhere in the Region.

While it is ecologically possible to greatly improve the rangelands by paying attention to the species best adapted to the various agro-ecological zones (Dewan and Famouri 1964; Mobayen and Tregubov 1970), the economic practicability is a major deterrent. Rangeland rehabilitation is a long-term aim but no solution to the short-term and immediate needs of the grossly-underfed Iranian livestock population. Clearly, the most promising potential source of livestock feed is in the rainfed and irrigated cropping areas. With better attention to agronomic practices especially with regard to use of water and fertilizers in the irrigated areas, and weed control and fertilizers in the rainfed areas, there is great scope for increasing cereal yield and production (Anon 1970; Sadri and Payman 1977) thereby releasing substantial areas for production of pastures or forage crops for the various livestock. Any land released from cereal cropping following achievement of self-sufficiency in cereal production is likely to be marginal land in the rainfed areas which is best allowed to revert to rangeland. Similarly, in the irrigated areas the first to be released is likely to be that which is affected to some degree by salinity which land could well be sown to a salt-tolerant alfalfa or *Trifolium fragiferum* on a long-term basis.

Van der Wal and Shamsi (1972a, b) demonstrated the far greater potential yields of maize and other warm-season forage grasses than alfalfa or sainfoin when grown under irrigated conditions with fertilizer in Iran. However, it is unlikely that significant areas of irrigated land can be set aside for perennial forage-crop legumes like alfalfa and sainfoin though, as mentioned previously, this is a possibility in some salt-affected areas in the irrigated districts. Annual pasture or forage-crop legumes e.g., *Trifolium alexandrinum* and *Trifolium resupinatum* (Persian clover) have considerable scope in the warmer irrigated areas.

By far the largest potential source of livestock feed in Iran is through better utilization of c. 7 million ha of fallow areas in the rainfed and irrigated areas. It is not unreasonable to assume that 5 million ha of fallow can be used for production of legume-based forage crops and pastures. Although the Forest and Range Research Institute and Forest and Range Organization, also other agencies, have been closely involved in evaluation of many species, and have actively encouraged regeneration of rangelands or the artificial improvement of

native rangeland areas with introduced species and cultivars of herbage plants, little has been done with regard to evaluating annual legume species for sowing on the fallow land. However, there is ample evidence that there is a wide range of well-adapted, potentially-useful species and local ecotypes of legumes. These need to be evaluated for both the rainfed and irrigated cropping areas paying special attention to nitrogen fixation, dry matter production, protein levels, changes of digestibility with maturity, seed production, level of hard-seededness and ability to self-regenerate after a crop. The many native legumes include annual species of *Medicago* (high percentage of hard seeds) in the Gorgan area, *Trifolium resupinatum* (low percentage hard seeds) and various species of *Vicia* (with differing degrees of hard-seededness which can be fitted into a rotation with wheat or barley in the traditional cropping areas of Iran.

Australian cultivars of annual medics have performed well in the mild climate of the Caspian Coastal Zone. Pods from a rotation experiment on a rather saline soil at c. 100 m altitude near Shah Mazraee (Army Farm) some 50 km N.E. of Gorgan were collected on June 17, 1977. There were some medic contaminants on the plots but true-to-type pods of *Medicago truncatula* cvv. Borung, Hannaford and Jemalong; *Medicago littoralis* cv. Harbinger; *Medicago rugosa* cv. Paragosa and *Medicago scutellata* (Commercial snail medic) were collected. A few days later the pods were put on test on well-moistened filter papers in Petri dishes at room temperature (c. 19°C; air conditioned). At 7 days there was no germination from any species. Pods were dissected and all seeds were seen to be hard (i.e. impermeable). However, nothing is known of the rate of breakdown of hard-seededness in annual medics or other legumes during the Iranian summer.

At another site (Chalaki Research Station near Kordkoy in the Caspian Coastal Zone) a seed-increase area of *Medicago rugosa* had clearly given very high seed yields. However, in this area it would appear that rather than use an annual medic, a vetch or other legume (e.g. Persian clover) without hard seeds might be better suited to grow in rotation with cotton. Normally the land for cotton is ploughed in April and the cotton sown in May and picked from September to November. Wheat in this Caspian Coastal Zone is normally sown in November and harvested in June. Thus cotton and wheat do not form an ideal rotation because of the months of wasted potential growing period. However, a short-season vetch or other legume could be used as a grazed forage crop or hay without regard to seed-set - just as in the cotton areas of coastal Turkey where *Vicia sativa* cv. Kara-elci (with no hard seed) and other vetches are being grown in rotation with cotton and greatly improving soil fertility for the cotton crop as well as providing additional income to the farmer.

There are several potential sources of increased feed supply for livestock in Iran. First it is reasonable to assume a potential mean increase of 2500 kg DM/ha by sowing pasture or forage-crop legumes on 5.0 M ha of the existing fallow area in the rainfed cropping areas to give a potential increase of 12.5 M t DM. Furthermore, the enhanced fertility of the cereal belt through use of legumes in rotation and/or use of fertilizers should give an increase of 2.5 M t of edible straw. On about 0.4 M ha of irrigation lands (in warmer areas) it is realistic to grow winter legume species e.g. *Vicia* or *Trifolium alexandrinum* or *T. resupinatum* with a mean increase of 5000 kg DM/ha giving a potential increase of 2.0 M t DM. The retraction of both rainfed and irrigated crops from marginal areas made possible by improved agronomic practices resulting in increased cereal yields should give a potential for a further 2.0 M t DM in pasture or forage crop. There is great scope for increasing feed supply by more efficiently using water in irrigated areas by using more fertilizers and also by applying phosphatic fertilizer to non-arable hill lands bordering the Caspian Coastal Zone and in north-west Iran. This should give a further increase of 3.0 M t DM. Hence, at a conservative estimate, there is scope for producing an additional 22.0 M t DM, sufficient for 27.5 million ewe equivalents. These sources of feed would allow a very considerable reduction in grazing pressure on the rangelands and provide scope for a realistic programme of rehabilitation of those grazing areas in greatest need of attention.

PLATE 6IRAN

In the Gorgan area (near Caspian Sea) hard grazing of cereal stubbles by cattle (left) or by sheep presents no great erosion risk on these flat areas, providing there are residual seed supplies for regeneration of volunteer pasture following the cereal crop. This area is suited to annual self-regenerating *Medicago* species (either Australian cultivars or native ecotypes).

(Photographs: Gorgan region, June 1977).

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IRAN

Control of grazing by goats (left) is of high priority in the Khorramabad area (and other areas) if degradation of rangelands and excessive run-off and water erosion is to be arrested. Where livestock have been excluded from grazing, or grazing has been carefully controlled, regeneration of native grass, giving excellent protection to hill country, has resulted as in the Nogeian protected area (right).

(Photographs: Khorramabad region, June 1977).

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IRAN

In the Sanandaj area severe gully erosion of cereal-cropland could be avoided by contour tillage and properly-constructed grassed waterways. This presupposes joint action by all concerned - including the shepherds, as many of the deep gullies originate from livestock tracks. At right is shown a small flock owner following traditional right of grazing cereal stubble.

(Photographs: June 1977).

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IRAN

The high mountain areas of the Tehran region are most-importantly a water catchment area and the principal objective should be to ensure clear-water runoff to minimise siltation of reservoirs and irrigation works, even if this means temporary or permanent exclusion of livestock. While *Trifolium ambiguum* will undoubtedly prove useful for providing ground cover one native species of particular promise for the highest altitude areas (>3000 m) is *Trifolium radicosum* a prostrate, rhizomatous, deep rooted perennial shown at right.

(Photographs: June 1977).

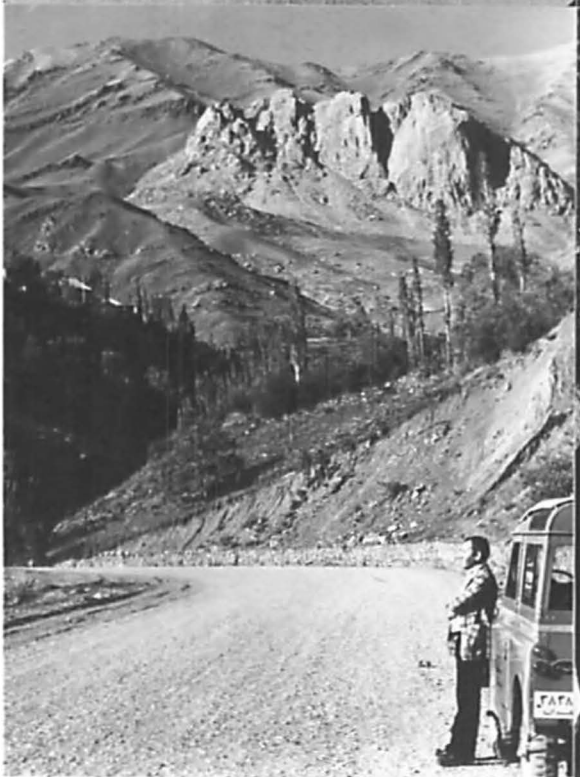


PLATE 7IRAN

In the Caspian Sea area at the Pasand Research Station of the Forest and Rangeland Research Institute, the mild winters and humid summers enable both temperate and sub-tropical species to thrive. *Pennisetum orientale* is shown on the left and *Lotus corniculatus* at right.

(Photographs: June 1977).

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IRAN

The second hay cut on a grass-legume meadow in Kurdistan (left) and traditional transport of cured meadow hay (right) in Arak region. When crudely chaffed this hay sells for some US\$110/t at harvest time and frequently in excess of US\$150/t in winter.

(Photographs: June 1977).

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IRAN

Typical roadside grazing by sheep and goats and preparation of dung for fuel in Borujerd region (left). At right is shown extensive lot feeding facilities associated with the Tergaran Fattening Project near Khorramabad.

(Photographs: June 1977).

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IRAN

Tergaran Fattening Project near Khorramabad has 50 receival-feeding sheds of the type shown: exterior (left) and interior (right). Nine satellite fattening units (of the type shown above right) are attached to this main receival headquarters.

(Photographs: June 1977).



PLATE 8TURKEY

The native and naturalized pastures of the Erzurum region of Eastern Anatolia at an altitude of > 2000 m have an abundance of grass and legume species providing rapid growth and good grazing as the snow cover recedes (left). Members of the Faculty of Agriculture, Ataturk University, Erzurum in sown pasture on land degraded by former cropping (right).

(Photographs: June 1977).

TURKEY

Typical sheep flock grazing on weed fallow in the Ankara region of Central Anatolia which generally carry a wide range of free-seeding annual and perennial species (left). Early tillage greatly reduces the feed supply of livestock. Wheat production in Turkey has increased dramatically through an effective programme involving use of high-yielding-varieties improved agronomic practices and extension (right).

(Photographs: June 1977).

AFGHANISTAN

Nomadic herds and flocks are an important component of the livestock industry of Afghanistan. The typical tents in a common grazing area north of Kabul are shown at left. At right is one example of the size of the fat reserves - in this case a fat-rumped young Arabi ram with one lobe of fat on each side of the tail.

(Photographs: July 1977).

AFGHANISTAN

Camel herd grazing fresh growth of camel thorn (*Alhagi camelorum*) in Ghazini Province (left) and native grasslands of the Baghlan region of northern Afghanistan (right).

(Photographs: July 1977).



## 9. Afghanistan

The visiting in Afghanistan involved the following road travel to see and discuss dryland and irrigated crop production and general ecology and land use:

- (i) Kabul-Baghlan and return;
- (ii) Kabul-Kandahar-Lashkargah-Herat and return via Kandahar to Kabul; and
- (iii) Local travel to Ministry of Agriculture offices, the University College of Agriculture and the UNDP/FAO offices in Kabul.

These visits and discussions gave a clear indication of some of the major constraints to agricultural production, particularly in the pasture-livestock sector. The travel showed a range of examples of dryland and irrigated crop production and grazed pastures varying from the mountain meadows north of Kabul through the grasslands of the Bay Saqal Range Improvement Station in the Baghlan region to the extensive *Artemisia herba-alba* rangelands of the semi-arid areas of the Kandahar-Herat region.

The crop ecological zones of Afghanistan have been described by Rafiq (1976). As in other countries of the Region, the main emphasis in Afghanistan agriculture has been on crop production (wheat the main food crop and cotton the main cash crop). Of the total crop area of 3.79 M ha in 1975, cereal crops accounted for 3.38 M ha (89.3%) while legume crops (all pulses) occupied only 34,000 ha (0.9%). While animal health has received a good deal of attention, there has been a gross neglect of rangeland resources in terms of both watershed management and supplying feed for livestock. This is reflected in the critical shortage of qualified staff in the broad fields of rangeland management and soil conservation. Again, there is inadequate coordination of agricultural planning - one group encouraging mechanization of agriculture which inevitably leads to exploitation of rangelands, while others are desperately trying to arrest the tragic decline in the rangelands. Although there are laws restricting ploughing of marginal lands, e.g. areas that are too dry or too steep, these laws are commonly abused. These problems are exacerbated by the large population of transhumant people especially in northern Afghanistan and the 2 million true nomads (Kochi) of western Afghanistan.

Officers of the Forest and Rangeland Department of the Ministry of Agriculture estimate that there are 16 million ha of winter pasture lands, 16 million ha of spring/autumn pasture lands and 22 million ha of summer pasture lands, this area of 54 million hectares ranging from 400 m - 3600 m altitude. The autumn and spring rangelands are used by nomads in migration. Clearly, with these great differences in altitude transhumant grazing systems should be the most efficient - provided that livestock numbers are contained at reasonable levels.

Most of the research and extension efforts of the Ministry of Agriculture are directed to improving crop production: however, it is quite obvious that there has been a disastrous decline in rangeland productivity as shown in large tracts between Kabul and Kandahar and between Kandahar and Herat. There is clear evidence of degradation of rangelands in the Herat area, and the complete depletion of *Pistacia* trees (used for fuel) on huge areas and the uprooting of rangeplants for fuel is a national tragedy. Clearly there are technical problems in arresting degradation of rangelands, and improving the existing rangelands: but, in addition to the ecological problems, there are major socio-economic constraints related to demarcation of grazing areas and allocation to worthy villages and tribes. This requires major political initiatives and administrative action. For this reason there are clear needs for sound research to demonstrate the decline of rangeland productivity and the increased soil erosion to provide the hard facts to convince policy makers.

In the Helmand Valley scheme considerable progress has been made with integrated agricultural development but there are many soil areas - saline, shallow, poorly-drained, etc. - that are not suited to irrigation: thus the economic viability of some of the irrigated areas is open to question.

So far as animal production is concerned the main emphasis in the past has been on animal health but the real problem is undernutrition. Various estimates have been made but a common figure is that current feed supplies in Afghanistan are sufficient to sustain only about two thirds of the present livestock numbers. Consequently, there have been some catastrophic losses due to the prolonged lack of feed, parasites and cold winters. The fact that some 80% of sheep or goats migrate to a varying degree each year complicates quarantine, health inspection and disease-control programmes. The Karakul sheep industry (mainly in northern Afghanistan) is important : Karakul pelts, along with wool of other breeds, generate a substantial part of export earnings. Karakul sheep numbers (c. 7 M) are normally one third of total sheep numbers which are usually about 22 M but are currently down because of severe losses due to recent droughts. The Pusa Esam Government Karakul Farm in Baghlan Province is concerned with ensuring (through production and distribution to the farmers of high-quality rams) that good types of Karakul sheep and lambs are being produced.

A good example of the relative neglect of the pasture/rangeland resources was provided by Ministry of Agriculture staff allocation in Herat Province, where, in July 1977, 1 qualified technician with some aid from 10 Forestry/Range Inspectors (with donkey transport only) was responsible for control of the large area of rangeland (exceeding 1.5 M ha) yet there were 11 veterinary clinical staff, 15 laboratory diagnostic staff and 5 visiting Russian experts making 31 qualified people concerned with animal health. This is not to imply that problems of animal health are not important but rather that the rangeland feed resources, which have a major influence on bodyweight and susceptibility of livestock to disease, are being grossly neglected. The fact that there is no clear line of demarcation between rangeland and cropland in Herat Province aggravates the problem of shortage of qualified rangeland management staff.

So far as research and training is concerned, as previously mentioned, very little has been done except on cereals. While there has been some useful documentation on forest resources (e.g., Nedialkov 1975) and some useful contributions on the rangelands and their utilization e.g. Keshtyar ( ), McArthur *et al.* 1975, 1977; Synott *et al.* 1977) there appears to be little critical experimentation related to the possible role of legumes in rotations in the croplands. Although mung beans are used in rotation with wheat in the Helmand Valley Project and in other irrigated areas and some chickpeas, lentils and broad beans are grown for human consumption, the total area of pasture and forage-crop legumes is very small. While some alfalfa, Persian clover and berseem clover have been grown for animal feed in small rainfed and irrigated areas for a very long time, in recent years there is renewed interest in the annual forage-crop legumes and pasture legumes. Species of vetch and annual medics are being tried on an experimental basis in the Herat area by the Herat Livestock Development Corporation (HLDC), and elsewhere.

There are some urgent agricultural problems in Afghanistan but the lack of rural infrastructure, trained researchers and transportation, also the inadequate salaries and living expenses received by research workers, cannot create the necessary research environment. It would appear that at least part of the deficit in trained agricultural scientists could be alleviated by promoting better coordination and cooperation between the Faculty of Agriculture of Kabul University and relevant Departments of the Ministry of Agriculture. Faculty Members, with the aid of students, could help with many urgent problems needing agricultural research. However, as a prerequisite for successful cooperative research projects it is urgent that existing serious constraints like the fact that employees of the Ministry of Agriculture have quite inadequate transport to properly fulfil their duties, and also that their *per diem* is quite inadequate to meet costs of meals and accommodation when away from home, should be removed. Such constraints are a major disincentive to undertaking relevant, site-specific research.

By encouraging better integration of crops and livestock through taking full advantage of the complementarities of the irrigated areas, rainfed crop areas and rangelands of Afghanistan, coupled with more incentive for off-take of young livestock and non-productive animals through provision of feed-lot fattening and slaughterhouse facilities, there is every reason to believe that the livestock industry of Afghanistan could be greatly stabilized to the benefit of both Government and producers. The World Bank-funded integrated programme of the HLDC at Herat which involves agricultural credit, range management, sheep management and production and slaughterhouse operations designed to assist the orderly offtake of sheep to the Iranian market is one example of a potentially-valuable stabilizing influence on the sheep industry. While it is urgent that there be more administrative controls to prevent overgrazing, prevent the reckless ploughing of rangelands, and prevent the uprooting of rangeland shrubs and trees for fuel, thus helping to arrest deterioration of the rangelands, these controls will best be achieved by ensuring that there are alternative feed supplies for the nomads (Kochis).

Livestock feed supply in Afghanistan can be increased in several ways. First there are about 4 M ha of fallow each year of which it is reasonable to use say 2.4 M ha for the production of leguminous forage crops e.g., short-term cold-tolerant *Vicia* spp. or longer-term *Medicago sativa* or *Onobrychis sativa*. With phosphatic fertilizer and other needed inputs this area may well increase the current feed supplies by an average of 2500 kg DM/ha giving a total increase of 6.0 M t DM, as good quality leguminous hay - or in part as grazing. The second opportunity for substantial increase in livestock feed supply lies in the irrigated areas where currently only 12% of the irrigated crop receives fertilizer. This amounts to a reckless waste of water and potential crop yield. If fertilizer and other important inputs are used on all irrigated lands then yields per hectare could be increased to such a level that substantial areas of irrigated land could be released for forage crop production and/or cereal production. There should be significant opportunity to produce substantial quantities of both leguminous and warm-season grass forage crops (e.g. maize, sorghum, millet). Senior staff of the Helmand Valley Project suspect that they may well be wasting 30% of irrigation water. Certainly a good deal of wastage of irrigation water may be seen between Kabul and Baghlan. No doubt there is wastage of water through inadequate levelling of irrigated sites in other areas. Thus, improved agronomic practice including choice of species and fertilizers, and the economic use of irrigation water provide a great potential for increased livestock feed supply. The increase in crop yields and consequent production will result in an increased amount of stubble grazing<sup>+</sup> available to livestock and quite conceivably release some areas to revert to dryland range.

Having regard to the potential changes in the irrigated areas (c. 2.6 M ha) resulting from greater use of purchased inputs and more efficient use of irrigation water, it is not unreasonable to envisage an additional 12.8 M t DM as livestock feed being produced in the existing and potential irrigated areas. This potential additional feed supply from the irrigated areas, together with the suggested potential increase in feed supply from the fallow lands, totals 20 M t DM which is sufficient for 25 M ewe equivalents. In addition, there is an undoubted potential to increase feed supply on some of the wetter grasslands and mountain meadows by topdressing with phosphatic fertilizer to encourage production of native legumes, consequent nitrogen fixation and increased productivity of non-legume components. This may well give a further increase of 4 M t DM. Thus the total potential increase in feed production in Afghanistan is of the order of 24 M t DM which is sufficient to support 30 M ewe equivalents.

The potential increase of 24 M t DM in livestock feed supply in Afghanistan will not be achieved quickly or easily. It will require a sustained and coordinated effort by relevant Government Ministries along with investment in research and training, fertilizers and seeds and agricultural machinery. However

<sup>+</sup>1.2 M t DM.

even if half this increase is achieved in the foreseeable future this is enough for the feed requirements of about 15 million ewe equivalents. Furthermore, the reduction of grazing pressure on the rangelands made possible through the production of an alternative feed supply will allow the slow rehabilitation of degraded areas and a general increase in productivity of these lands. These proposals for increase in livestock feed supply would enable the Government of Afghanistan to achieve its projected 1983 goal of 25.9 M sheep and 4.3 M cattle, as outlined in the First Seven-Year Economic and Social Development Plan 1355-1361 (March 1976 - March 1983) from the Ministry of Planning, Kabul.

#### 10. The Potential Impact of the Widespread Use of Legumes in the Region

The foregoing country descriptions have shown that there is no shortage of well-adapted native legumes in the Region but these have been grossly neglected - in part because of the lack of organized seed industries. There is ample evidence that these legumes could fulfil the same role in increasing livestock production and, through increasing soil nitrogen, cereal crop production in the Region - as in southern Australia. The solution to the shortage of livestock feed and the consequent degradation of rangelands in the Region lies in providing alternative feed supplies in the traditional rainfed and irrigated cropping areas through the widespread use of pasture and forage-crop legumes on fallow and other under-used cropland areas. It is quite unrealistic to expect to continue to overgraze the arid and semi-arid rangelands without completely destroying these grazing resources. The challenge is to prevent further degradation of these fragile ecological areas through greatly increasing feed production in the rainfed and irrigated cropping zones and transferring livestock and population to these areas. Suitable pasture and forage-crop legumes and realistic crop-livestock integration are prerequisites for the success of such changes.

Table 14 gives estimates of potential N-increment based on the proposed establishment of properly-nodulated pasture and forage-crop legumes on some 23 M ha of the 30 M ha of fallow in the nine countries covered in this report. Assuming a mean net input of 60 kg N/ha, this large area of legumes would give an annual increment of 1.4 M t of N which is 65% greater than current use of fertilizer nitrogen (Table 14): this should greatly increase cereal crop production and/or save large investment in fertilizer nitrogen. The sources of potential increase in feed production and the corresponding number of ewe equivalents for the same nine countries are shown in Table 15. No doubt the table contains both over-estimates and under-estimates so that the figures must be regarded as tentative. And, of course, Government policies on land use: e.g. forest vs. pasture in humid hill country; or food legumes vs. forage-crop legumes in the rotation in the cereal zone; or cash crop vs. forage crop on irrigated areas could modify these estimates. However, there is unequivocal evidence that very much more livestock feed can be grown in the Region without necessarily resulting in any decrease in the production of cereal crops or food legumes. On the contrary, there is clear evidence in the Region that livestock feed and cereal crop yields can be increased concurrently - due mainly to improved levels of soil nitrogen following the establishment of pasture and forage-crop legumes on areas previously left as weedy fallows.

From the foregoing country statements and Table 15 it is concluded that:

- (i) the main increase in livestock feed supplies will come from the rainfed cereal and humid zones (83.1%) and much less from the irrigated areas (16.9%);
- (ii) no increase of feed supply can be expected from the semi-arid and arid rangelands until these areas have been rehabilitated; and
- (iii) there is a great need to develop potential interzonal complementarities by encouraging relevant crop-livestock integration.

These facts point to clear priorities in agricultural research and development in the Region: these will be discussed in the next section.

TABLE 14

THE EXISTING EXTENT OF FALLOW AREAS, USE OF NITROGENOUS FERTILIZERS AND ESTIMATES OF POTENTIAL ANNUAL NITROGEN INCREMENT FROM USING LEGUMES ON MUCH OF THE FALLOW

Country	Existing		Potential	
	Total Fallow Area (M ha)	Fertilizer N <sup>+</sup> (t)	Legume Area (M ha)	N-Increment <sup>*</sup> (t)
Afghanistan	4.0	27,668	2.4	144,000
Algeria	3.0	62,800	2.5	150,000
Iran	7.0	194,480	5.0	300,000
Iraq	2.0	25,000	1.5	90,000
Jordan	0.2	1,900	0.15	9,000
Libyan A.R.	0.5	15,000	0.4	24,000
Syrian A.R.	2.5	42,000	2.0	120,000
Tunisia	1.5	18,000	1.2	72,000
Turkey	9.0	452,620	8.0	480,000
Total	29.7	839,468	23.15	1,389,000

<sup>+</sup>Data for 1975/76 season as given by FAO (1977c).

<sup>\*</sup>Assumed mean net increment of soil nitrogen = 60 kg/ha/annum.

TABLE 15

ESTIMATES OF POTENTIAL INCREASES IN LIVESTOCK FEED SUPPLY FROM THE RAINFED AND IRRIGATED ZONES AND EXTRAPOLATION IN TERMS OF CARRYING CAPACITY

Country	Potential Increase in Feed Supply (Million, Metric Tons DM)				Carrying Capacity <sup>+</sup> (Million, Ewe Equiv.)
	Cereals Zone		Humid Zone	Irrigated Zone	Total of Three Zones
	Pastures & Forage Crops	Crop Resi- dues	Pastures & Forage Crops	Pastures & Forage Crops	Pastures, Forage Crops and Crop Residues
Afghanistan	6.0	1.2	4.0	12.8	30.0
Algeria	10.0	1.2	8.0	-	24.0
Iran	13.5 <sup>x</sup>	2.5	3.0	3.0 <sup>x</sup>	27.5
Iraq	6.0	0.8	2.0	0.8	12.0
Jordan	0.45	0.075	0.075	0.04	0.8
Libyan A.R.	1.2	0.24	-	-	1.8
Syrian A.R.	7.0	1.0	1.76	2.24	15.0
Tunisia	4.8	0.6	1.0	-	8.0
Turkey	20.0	4.0	2.0 <sup>φ</sup>	2.0 <sup>φ</sup>	35.0
Total	68.95	11.62	21.83	20.88	154.1
Percentage	55.93	9.42	17.71	16.94	100.00

<sup>+</sup>Because of the current excess of livestock numbers over feed supplies it should not be inferred that these figures represent potential increased carrying capacity merely the numbers of ewe equivalents supported by the potential increase in feed supply. 1 Ewe Equivalent = 1 Breeding Ewe = 1.5 Dry Sheep Equivalents. It is assumed that 800 kg DM produced (mainly pasture and forage crop) with 85% consumption is sufficient for 1 ewe equivalent/year.

<sup>x</sup>The 2 M t DM mentioned on p.48 is allocated equally to these two zones.

<sup>φ</sup>The 4 M t DM mentioned on p.45 is allocated equally to these two zones.

#### IV. RESEARCH PRIORITIES FOR PASTURE-LIVESTOCK PRODUCTION IN THE REGION

##### 1. General Considerations

In previous sections of this report mention has been made of the fact that it is unrealistic to segregate cereal production and livestock production enterprises in the Region and that there is a great need for cereal-livestock integration. However, in view of the excellent progress made by the various national and international agencies in raising cereal production in the Region, no direct reference will be made here to research on cereal production, although there are some obvious areas of common concern (e.g. tillage practice, time of sowing in relation to establishment, optimum fertilizer use). Thus the emphasis in this section will be on research priorities directly related to pasture and forage-crop production and consequent livestock production.

In the Region there is a clear need for new farming systems involving the integration of crop and livestock enterprises. There is need to demonstrate that sheep can be kept all-year-round on cereal farms. Problem-orientated research is needed to assess the biological and ecological possibility and potential for increased livestock production while concurrent research studies are required to show the social and economic practicability of new systems of production. Integrated research studies must be amenable to both statistical and economic analysis. Technological research is wasted if the results cannot be applied, or adapted, or are unacceptable because of cultural, social or economic constraints.

For an effective programme of research on pasture and livestock production to meet the increasing demands of the human population in the Region, multi-disciplinary research involving specialists in soil fertility, soil water, pasture and crop agronomy, rangeland ecology, livestock production (feeding, selection and breeding) and socio-economics is required. In this respect it is essential to ensure fully-co-ordinated agricultural research in the Region. It would appear that more liaison and co-ordination of efforts is needed between the various national groups, and between national and international groups to ensure maximum benefit from both local and overseas research. Staff and students at the Universities should be involved more in helping to ensure continuity of research effort into important local agricultural problems. Many relatively simple, but important, agricultural problems could well be tackled and answered for differing environments and in sequential years by a series of thesis studies (see IV, 4.).

The research priorities for the Region have been given in previous reports (Skilbeck *et al* 1973; Carter 1974b, 1975a) but those aspects relating particularly to the pasture-livestock sector will be emphasized again. It should be stressed that a great deal of data and information based on research and experience exists in the Region but is generally unavailable through lack of widespread publication. Thus it is often inadequately known inside and unknown outside the country. Because of these problems, the various international organizations can have a particularly valuable co-ordinating role in helping to disseminate existing knowledge and promoting co-operative research within and between countries of the Near East and North Africa.

Besides ICARDA, the existing bilateral and multilateral agencies involved in agricultural research in the Region include the following:

\* The Arab Centre for the Studies on Arid Zones and Dry Lands (ACSAD): This group, under the leadership of Director-General Dr. Mohamed El-Khash is headquartered in Syria and is involved in a wide range of research and training projects in the Arab countries. Range improvement studies commenced in 1973 using exotic and indigenous species in re-vegetation work. Rangeland surveys have been made in several countries: the objective is to make a rangeland resources map for the Arab World. Other activities include a cereal improvement programme, studies on pasture and forage-crop legumes and selection and cross breeding studies with Awassi sheep. Selected Awassi rams from the El Kreim Centre

for Sheep Improvement in Hama Mohafazat in Syria are dispersed to the Arab League countries in the Region. ACSAD is a key organization in the Region (El-Khash, personal communication).

\* Food and Agricultural Organization of the United Nations (FAO): This organization has important projects in all countries of the Region but the outstanding regional activity is the UNDP/FAO Regional Project on Improvement and Production of Field Food Crops in the Near East and North Africa (FAO 1975) under the able and dedicated Project Leader Dr. Abdul Hafiz. This project has an important co-ordinating role involving research, extension and training on winter cereals, summer cereals, oil seed crops, food legumes, pasture and forage-crop legumes, also production and irrigation agronomy in the Region. The project helps provide postgraduate, production-orientated training to research workers - for example Ph.D. studies on the role of legumes in farming systems at the Waite Agricultural Research Institute, and a one-year diploma course in Australian farming systems at Roseworthy Agricultural College in South Australia. It is important to record the generous financial support, and assistance in training and through supply of equipment, etc. to this FAO Project that is provided by DANIDA (Denmark), NORAD (Norway), SIDA (Sweden) and by the Government of Saudi Arabia who *inter alia* has financed the sending of 50 local scientists from the Region to undertake the special course mentioned above at Roseworthy Agricultural College. This number is based on an average of 10 per year for 5 years.

\* Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT): This International Centre has had long-standing commitments in the Region related to improvement of wheat and maize and the associated technology needed for best results from the High Yielding Varieties. In Tunisia and Algeria there have been active programmes related to agronomic practices e.g. tillage and weed control and also specific programmes related to use of the annual *Medicago* spp. in crop rotations (Carter 1974b, 1975a; Doolette 1976; Nelson 1976; Saunders 1976).

\* Other Agencies: In addition to the abovementioned organizations, many other bilateral agencies (e.g. the French and German foreign-aid agencies in Algeria and Tunisia, The Rockefeller Foundation, The Ford Foundation and USAID) are active in the Region comprising the Near East and North Africa. Hence there is a real challenge to ensure adequate co-ordination of research effort (and advice given) in the various agricultural sectors in the Region. Because of its mandate for research and training in the Region, ICARDA has a responsibility to take an active role in co-ordination of several agricultural research efforts in the Near East and North Africa (See Appendix C and IV, 4).

Despite the research efforts of the national groups supported by the international agencies, there are still major agricultural problems in the Region. These problems fall into four major research areas which generally come within the terms of reference of ICARDA, viz:

- (i) Soil and Water Management: This includes soil structure, soil permeability; fertility and fertilizers; irrigation, drainage and soil salinity.
- (ii) Field Crop Production: This includes crop-plant improvement and technology of production; tillage practices (shared with (i)); crop sequences and rotations.
- (iii) Pasture-Livestock Production: This includes pasture and forage-crop improvement; the inter-zonal complementarities of the arid and sem-arid rangelands, the cereal zone, the higher-rainfall (humid) zone and the irrigated zone; the technology for increasing livestock feed through use of pasture and forage-crop legumes in the traditional rainfed and irrigated croplands.
- (iv) Socio-economic Studies: This includes topics like the role of agricultural credit, price incentives, storage and marketing; the impact of mechanization on employment and production; the role of machinery syndicates, contractors, co-operatives, etc.

The integration of the findings from these four abovementioned areas of research will provide the basis for any new farming systems. These systems will need to be modified according to climate, soil, locality and socio-economic state at the farm, the village, the province and the country level.

While some excellent research has been done in the Region, much of the field research lacks quality and relevance. The frequent, though unacceptable, discrepancy between crop yields at Research Stations and those commonly obtained by the farmer highlights several problems. While it is the duty of research workers to establish the biological maximum yields i.e. establish the ecological possibilities of a particular cultivar with maximum inputs it is also the responsibility of agricultural scientists to establish the economic practicability of various combinations of inputs i.e., to establish a range of options. We know that, for various reasons, many farmers will not or cannot use adequate fertilizer and other optimal cultural practices, therefore in formulating recommendations these facts have to be considered. More experiments are needed on farmers' fields using farmers' methods. These need to be side-by-side with experiments using a range of inputs (Carter 1977, Appendix C).

Agricultural research differs from many other sciences in that a great deal of the research is site-specific. Furthermore, most field experiments involving various levels of inputs designed to give a range of yields need to be amenable to both statistical and economic analysis. As many of the ecological, technical, social and administrative problems are site-specific, relevant and unequivocal local research results are needed to convince Government policy-makers of the need for change. Such research data requires relevant, high-quality field experiments.

One very disturbing but common feature of the research and development in the Region is the number of experiments undertaken on both rainfed and irrigated lands without the use of any fertilizers. Even if there are practical or financial constraints limiting the use of fertilizers by farmers at least fertilizer treatments should be included. It is quite unrealistic to continue to use irrigation water without concurrent use of fertilizers and plant protection technology. Currently there is enormous wastage of crop-production potential in irrigated zones in the Region - firstly, through inadequate use of fertilizers, fungicides and insecticides and secondly, through poor watering practices - under-watering and over-watering through inadequate levelling of the irrigated areas - such practices contributing to the growing salinity problems in the Region. With regard to the rainfed lands, vetches and other legumes have been commonly evaluated for yield without using phosphatic fertilizer treatments: hence on many sites the potential yields and consequent nitrogen fixation are no doubt greatly underestimated.

Another general regional problem, related to the research needs to maximize the use of home-grown livestock feeds, is the fact that several countries have been exporting potentially-useful livestock feeds, e.g. cane molasses and beet pulp at prices about half of the inherent local feed value. In view of the gross deficit of livestock feed and fodder reserves in all countries of the Region, such practices are inexcusable.

A major constraint to agricultural research, planning and development in many countries of the Region is the lack of adequate and reliable land use capability maps. Such maps, incorporating information on soil groups and types (also slope, erodibility, etc.); agrometeorological data (especially rainfall, temperature and evaporation); and natural vegetation (steppe rangeland, grassland, forest, etc.) are vital to preparing an inventory of natural resources, for estimating existing and potential land use and for zoning of land for irrigation, for rainfed cropping, for permanent grazing (e.g. mountain meadows, humid zone and steppe rangelands) and for forestry and for urban purposes. There is a need for an improved network of standardized agrometeorological stations and equipment throughout the Near East and North Africa: in places this data is a prerequisite for preparation of reliable land use capability maps. Irrespective of the mapping this agrometeorological data is needed for the correlation of seasonal climatic and soils information with crop yields and crop and pasture phenological data; also the incidence of diseases and pests. Reliable precipitation, temperature, wind, evaporation and humidity data are essential for making critical studies on the biology and life cycles of pests and diseases in the Region also for making comparisons with homoclimatic zones in other parts of the world.

## 2. Research Programmes and Priorities for the Region

The stratification of the Region into four broad land use zones, viz: arid and semi-arid rangelands zone; the rainfed cropping zone; the humid pasture zone and the irrigated cropping zone has been referred to previously and especially in relation to the analogies between the agriculture of the Region and of southern Australia. However, in listing the research priorities these zones will not be treated separately because many of the problems are common to more than one zone. Furthermore, the suggestions relating to research will be confined to the pasture/rangeland-livestock sector because cereal crop and food legume production are receiving adequate attention. The major ruminant livestock problem of the Region concerns the declining area and reduced productivity of grazing land: i.e. there is a gross deficit of feed for ruminant livestock with consequential overgrazing of the rangelands. The advantages of interzonal complementarity in optimizing land use have been referred to previously: frequently the associated research programmes will likewise need to involve more than one zone.

In the Near East and North Africa there is need to measure productivity and monitor changes in the rangelands, quantify the main causes of rangeland degradation, assess the ecological possibility and economic practicability of regenerating degraded and denuded rangelands, and to seek ways and means of achieving meaningful crop-livestock integration in the various rainfed and irrigated cropping zones adjacent to the rangelands. Furthermore, research and extension is needed to show ways and means of: (i) increasing livestock offtake and productivity (there is a need for a tax on adult stock to provide additional incentive to reduce numbers); and (ii) increasing and stabilizing livestock feed supplies from pastures, forage crops, browse and fodder species and conserved fodder.

Within the various countries of the Near East and North Africa research capability and achievement varies greatly, thus it is difficult to allot priorities that embrace the whole Region. However, it is clear that most of the research effort has gone into the rainfed and irrigated cropping zones and that the pasture/rangeland-livestock sector has been grossly neglected. No doubt this neglect has arisen from the fact that the rangelands are mainly common grazing lands and that a high percentage of the flocks and herds are owned/managed by transhumant or nomadic tribes. Furthermore, having regard to the shortage of trained research workers in most countries of the Region it is quite clear that there is adequate, if not disproportionate, emphasis on plant breeding yet there is quite inadequate attention to cultural practices for the various crops and pastures in the Region. Tillage practices; time, rate and depth of sowing; fertilizer forms and rates; weed control; pest and disease control require much more attention and may well provide the main impact on cereal and forage-crop production in the next decade. Many more broadly-trained crop and pasture agronomists are needed in the Region to ensure real progress at the farm level. Better-trained, better-paid and more-mobile extension workers are needed for working with the farmers on the farms.

It is clear that considerable research effort has been or is being directed to rehabilitation of these arid and semi-arid rangelands throughout the Region. While it is not suggested that this work cease, it is most obvious that such rangeland rehabilitation is no solution to the short-term problems of the grossly underfed livestock flocks and herds. Hence a relatively greater research input must be made into upgrading existing natural pastures in the humid areas and improving production from mountain meadows by the use of phosphatic fertilizers and aim for a far greater production of livestock feed on the fallows of the Region (Tables 14, 15).

There are several areas of pasture-livestock research that have high priority in all nine countries covered in this report; in fact these research topics are of high priority in almost all countries of the Region. The objectives of this research programme must be to assist in increasing crop and livestock production and/or decreasing costs of production of agricultural commodities and

to assist in protecting and preserving the rural environment in perpetuity. Some short-term answers are needed to guide the policy-makers. In brief, the priority pasture-livestock research programmes cover three broad fields, viz: (i) quantifying existing pasture, meadow and rangeland resources; (ii) producing more livestock feed based on the widespread use of pasture and forage-crop legumes on the fallow areas; and (iii) reducing damage caused by overgrazing and reckless ploughing of steppe rangelands and steep and shallow soils. Important research programmes are outlined under the eleven headings -- (a)-(k).

(a) Collection and Analysis of Agrometeorological Data

As mentioned on page 59 there is a great need for an improved network of standardized agrometeorological stations throughout the Near East and North Africa. Reliable precipitation, temperature and evaporation data are prerequisites for extrapolation of research results from one locality to another within the Region: the collection and analysis of existing data have a high priority in any overall research programme for the Region. In addition to summarizing existing data, an experienced agrometeorologist could, for example, assist in the following ways:

- (i) in association with crop and pasture agronomists establish minimum rainfall requirements (on soils of various textures) for germination and emergence of crop and pasture species and also determine the probability of receiving effective follow-up rains for crop/pasture establishment and production;
- (ii) in association with a soil physicist and an irrigation engineer establish the water needs of irrigated forage crops having regard to potential evapotranspiration losses, also help to determine the water use efficiency of various irrigated forage crops at representative locations; and
- (iii) assist in the siting and installation of new well-instrumented meteorological stations at strategic sites throughout the Region.

(b) The Ecology and Production of Existing Pasture and Forage-Crop Species

The evaluation of existing native and natural pastures (including mountain meadows) in the cereal zones and higher-rainfall areas (humid zones) of the Near East and North Africa is of very high priority. It is important to assess current productivity in relation to potential productivity of these areas based on sowing additional legumes on fallow and/or use of fertilizers especially phosphatic fertilizer. Botanical surveys in spring with the Levy point quadrat (Levy and Madden 1933; Carter 1974b, 1975a) can greatly assist in quantifying plant density, yield and botanical composition. This data should indicate the likely role of fertilizers in encouraging pasture growth, especially in the case of annual legumes which are so important for increasing soil fertility and livestock feed supply, and for protecting the soils from erosion. These surveys should be followed by fertilizer experiments (with emphasis on rates of superphosphate), with and without the sowing of additional seed, in the following autumn to assess potential dry matter yields in various agroclimatic zones of the Region. These studies should include spring core-sampling for hard-seed reserves of *Medicago* spp. and *Trifolium* spp. where appropriate and summer sampling for total seed mass to predict the need for further seed on each surveyed area.

(c) Collection, Introduction and Evaluation of Pasture and Forage-Crop Legumes

The collection, identification, screening and evaluation of regional ecotypes of pasture and forage-crop legumes also introduced<sup>+</sup> lines of the same and different legume genera and species is of very high priority in any research programme in the Region. These species, cultivars or lines should be assessed under various levels of phosphatic fertilizers. Methods of establishment, persistence, the yield potential, seed production and self-regeneration of these species require study. As light competition, and/or moisture stress, will determine potential dry matter production in most situations (i.e. total yield of dry matter will be correlated with density) emphasis should be on ease of establishment, seed production, re-establishment and persistence of the annual legume species.

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<sup>+</sup>The introductions may well include species originally from the Region and perhaps indistinguishable from the current indigenous lines.

The relative merits of annual and perennial legumes along with the various degrees of cold tolerance, drought tolerance, length of the period from emergence to seed maturity, dormancy and hard-seededness and the rate of breakdown of hard seeds will need research. The recent introduction of Sitona Weevil (*Sitona humeralis*), the Spotted Alfalfa Aphid (*Therioaphis trifolii* f. *maculata*) and the Blue Green Aphid (*Acyrtosiphon kondoi*) to southern Australia has resulted in very severe damage to pasture and forage-crop legumes in the cereal zones and higher-rainfall zones. This has prompted a re-examination of genotypes by intensive screening for resistance or tolerance to these three pests (and others) in re-evaluating pasture and forage-crop legumes for southern Australia and the Near East and North Africa.

The specific *Rhizobium* requirements, if any, will need to be examined in a comprehensive programme of evaluation of pasture and forage-crop legumes. Furthermore, the effectiveness of nodulation in terms of symbiotic nitrogen fixation will need to be examined. The practical implications in terms of soil nitrogen increment is best evaluated in rotation experiments involving legumes - see p.63.

The enormous range of genera and species of pasture and forage-crop legumes in the Near East and North Africa shows the importance of properly screening existing material before embarking on any breeding programme. In the case of new genera or species, the evaluation should include feeding to sheep in pen-feeding tests and also subjection to differing degrees of grazing and treading pressure in field experiments with sheep. However, these are final evaluations following earlier rigorous standard tests used in any plant introduction/evaluation studies.

#### (d) Tillage Methods and Tillage Practices

The whole question of choice of tillage implements, tillage methods and tillage practices affects cereals and other crops as well as the potential of legumes in a rotation. Critical cost/benefit studies are needed in terms of costs of tillage, maintenance of soil structure and infiltration, maintenance or improvement of soil nitrogen levels, the amount of feed available for livestock and cereal crop yields. Ongoing research especially in relation to the merits of the long cultivated fallow period prior to the cereal crop is the most critical. Any assessment of the long cultivated fallow (bare fallow) must involve the complex interrelationships of costs of ploughing (or other initial tillage), costs of subsequent tillage, infiltration, water storage, weed control, seedbed preparation and sowing time. It also involves persistence of the self-regenerating medics and other legumes (see p.18), maintenance of soil nitrogen level and soil structure.

While some experiments have been done on time of ploughing in relation to subsequent yield of cereal crop, these have taken inadequate account of the value of livestock feed available on the fallow area. With introduction of legumes into this rotation the potential loss of livestock feed through early ploughing becomes even greater (see part (f)).

#### (e) Methods of Establishment of Pasture and Forage-Crop Legumes

Site-specific research is needed on the best methods of seedbed preparation, sowing and establishing the various legumes suited to the Region. These include the following matters which were discussed by Carter (1974b, 1975a):

- (i) the effects of various methods of seedbed preparation also time, rate and depth of sowing with particular reference to dry-sowing before the first rains vs. sowing after some destruction of weeds following early rains;
- (ii) The effects of minimum tillage with and without the use of herbicides for weed control (Carter and Saunders 1970);
- (iii) the effects of cover crops on establishment, herbage production and seed yields of legumes (Carter and Heard 1962; Carter and Saunders 1970);
- (iv) the effects of plant density on the productivity of dry matter and seed (Ragless 1973; Adem 1977), control of weeds, and growth of any associated cereal (e.g. vetch-barley);
- (v) the effects of seed size, sowing depth and soil texture on emergence; and

- (vi) the effects of phosphatic fertilizers (and possible other fertilizers, fungicides and insecticides) and inoculation with appropriate species of *Rhizobium*, on the establishment, productivity and nitrogen fixation of legumes.

(f) Rotation Experiments

While some research on the role of legumes in rotations has been done in the Region (Bilensoy 1970; Bakir 1976; Doolette 1976), many more cost/benefit studies using various pasture legumes (e.g. annual medics or clovers), forage-crop legumes (e.g. vetches, alfalfa or sainfoin) or food legumes (e.g. chickpea or lentils) in rotation with cereals are needed. Clearly the cereal-legume rotation must be assessed in relation to the traditional cereal-fallow rotation over the two-year cycle of the rotation (or longer in the case of perennial legumes) in terms of:

- (i) the relative costs of tillage and effects on soil structure and infiltration of water and soil water storage;
- (ii) the relative amounts of livestock feed or food legume produced;
- (iii) the relative levels of soil nitrogen - i.e. increase or decrease;
- (iv) the relative yields of cereal; and
- (v) the relative net financial returns from the two systems having regard to the long-term stability of both farming systems.

One aspect of the use of legumes in rotations that needs clarification relates to the desirable degree of hard-seededness and the pattern of breakdown of hard seed in the cropping year following the growth of the legume. In the case of the medics it would appear best if the medic retained a very high percentage of hard seeds which did not cause problems with a staggered germination and emergence after sowing the cereal crop. However, in the case of vetch it appears from the Syrian experience that it may be better to have no hard seed: this implies no carryover of seed through the crop year which means that, unlike the medic, it will need re-sowing after each crop.

In view of the climatic (mainly winter temperature) gradient from North Africa to the cold elevated areas of the Near East e.g. Anatolian Plateau of Turkey and the high plateaus of Iran and Afghanistan there are, on present indications, differences in the preferred legumes for use in rotations. In Algeria, Tunisia and Libya the Australian cultivars of medics, also vetches, peas and (in areas with sufficient rainfall and neutral to acidic soils) Australian cultivars of subterranean clover all appear to have a potential role in rotations with cereals. However, local ecotypes of medics with better cold tolerance should prove superior in the colder, higher-altitude areas. In Jordan, Syria and Iraq, which are generally colder than North Africa, then suitable vetches and peas with the necessary cold tolerance appear to be available. However, the existing Australian cultivars of annual medics and clovers seem suited to the milder winter areas, but of course, local cold-tolerant ecotypes of medics and clovers are of potential use. In Turkey, Iran and Afghanistan there is considerable merit in using alfalfa and sainfoin in long rotations with cereals. Again, promising local cold-tolerant vetches and peas are available for short-term rotations. Furthermore, in the lower-altitude areas of these three countries Australian cultivars of medics perform satisfactorily: but again, the local ecotypes should prove better adapted. In summary, there are ample legume cultivars (local or imported) to initiate valuable rotation experiments in the Region without waiting for final evaluation and commercialization of better-adapted local ecotypes of annual legumes though these should prove the best in the long term.

(g) Salt-Tolerant Pasture and Forage-Crop Species

Soil-salinity problems in both the rainfed and irrigated areas of the Near East and North Africa are of major concern. The collection, screening and evaluation of potentially-useful, salt-tolerant pasture and forage-crop legumes and grasses (and other families) is of high priority. The work of Elci (1975, 1976) needs encouragement, support and extension. Not only is this research (see p.41) of great importance to the Region but also to other areas of the world.

(h) Rangeland Ecology, Management and Utilization

It is a matter of high priority that existing rangeland resources be surveyed and mapped as part of the natural resource and land use capability mapping (see p.59). It is most important that research be initiated to:

- (i) determine the annual productivity (yield and botanical composition) of typical rangelands in various stages of degradation in representative ecological environments in the Region;
- (ii) quantify the main contributing factors (e.g. defoliation damage, treading damage, fire damage, ploughing or fuel collection) to degradation of rangelands in representative ecological areas of the Region; and
- (iii) assess the seed/seedling and plant species dynamics within and between seasons and monitor longer-term changes in response to management factors.

This data is required to demonstrate the existing and potential productivity of typical rangelands to assist in decision-making. It has been emphasized throughout this report that the rangelands are mainly degraded through overgrazing, etc. and the most urgent need is to reduce grazing pressure which is closely linked to the need to facilitate offtake of both young and older animals. The crucial prerequisite is the provision of alternative feed in the traditional rainfed and irrigated cropping areas (Tables 14,15). However, the technical complexities of providing additional feed for the nomadic and transhumant herds and flocks, and transport (e.g. road transport) to assist in transfer of these flocks and herds to alternative grazing areas, fattening areas or feedlot facilities, are less formidable than the need to instil new attitudes to cereal crop-livestock integration which will involve the whole socio-economic complex.

While it is ecologically possible to improve the denuded and eroded rangelands by furrowing or pitting to collect seed and water and/or by sowing indigenous or exotic species, this is usually economically impracticable except for a very special purpose like protecting a water catchment area. However, slow rehabilitation is possible providing grazing animals are excluded. Of course, sound range management practices such as rotation grazing and rest-rotation grazing to ensure adequate seed set are sufficient to allow regeneration in many cases, providing overall stocking rates are carefully controlled.

(i) The Management and Utilization of Pasture and Forage-Crop Species

At present, in the early stages of experimentation on ways and means of substituting grazed annual legumes for the fallow, and especially before a final choice is made of the best introduced cultivar (or cultivars) or local ecotype (or ecotypes) to use in a particular locality, there is no merit in attempting detailed grazing experiments as these are very expensive in terms of labour and other inputs of resources. However, there is merit in determining yield of the pasture or forage crop under grazing where total yield of dry matter is expected to exceed 9000 kg DM/ha. This is relatively simply done by the 'open' and 'closed' quadrat method of McIntyre (1946) cited by Carter (1974b, 1975a). Where total dry matter production of medic, clover, or other legume (plus grass and weeds) does not exceed c. 9000 kg DM/ha then a single end-of-season harvest for dry matter determination will adequately predict total yield but not botanical composition. Where yields are higher, more harvests are essential.

In the longer-term, detailed research is needed on the soil-plant-animal interrelationships of stocking rate, grazing method and type of livestock on both sown pastures and forage crops; also on methods of increasing annual herbage production by use of special-purpose pastures and forage crops, by fertilizers, by supplementary watering, etc.; and the utilization of the pasture or forage crop by *in situ* grazing, zero-grazing (cut and cart) and other methods. However, one matter that needs urgent study concerns the effects of deferred grazing and rotational grazing on seed production of rangeland plants. In the short term the important need is to accurately assess potential productivity of pastures and forage crops: this feed supply can then be extrapolated in terms of requirements e.g. 800 kg DM/year being equated with 1 ewe equivalent (Table 15).

(j) Fodder Conservation and Supplementary Feeding

The biological and economic advantages of conservation and feeding of pasture and forage crops, also grain and crop residues, needs careful assessment in the Region. The comparative advantages of feedlot finishing of sheep and cattle using green forage or dry fodder versus *in situ* grazing on green pasture needs careful study. This research will involve the compounding of feed rations from local feedstuffs. Research on maintenance feeding during the dry season using various conserved dry fodders and mixtures is also required.

With regard to these feeding studies it is essential to have *in vivo* and *in vitro* digestibility facilities, for at least checking the comparative digestibility by sheep of various locally-grown feedstuffs and mixtures. These facilities are needed by major livestock-producing countries in the Region.

(k) Management and Production of Sheep, Goats, Cattle and Camels

While the greatest constraint to increased sheep, goat and cattle production is the deficit in feed quantity and quality, there is scope for improvement by selection within existing breeds. With the anticipated provision of sown pasture and forage crops in the cereal zones, the higher-rainfall areas, and to a lesser extent in the irrigated zones, hopefully there will arise a settled livestock industry in many areas. This will require a more productive animal to better utilize the improved nutritional environment. Hence there will be scope for cross-breeding with exotic breeds. The potential quantity and quality of meat, milk, wool and mohair production will need evaluation for the various selections and cross-bred flocks and herds. With increased feed supplies, better animal offtake at a younger age will be possible but will require improved management which in turn will require research, for example on the following topics:

- (i) minimum and optimum age of weaning for sale or transfer of rangebred livestock to fattening areas or feedlots;
- (ii) optimum sire requirements and time of mating for nomadic and sedentary flocks and herds;
- (iii) flock and herd replacement strategy (age structure); and
- (iv) effects of yarding at night on the health and productivity of flocks.

3. Implications for the Countries of the Region(a) The General Situation: the Crucial Need for Investment in Agriculture

The objectives of agricultural scientists and administrators in this Region should be the same as in other areas of the world, i.e. be concerned with food and fibre production, providing an income and way of life for farmers, farm workers and associated agents and traders, and at the same time preserving the natural resources of cropping land, grazing and forest areas in perpetuity. However, in most countries of the Region there are serious deficits in the production of cereal grains, meat and milk for the rapidly-expanding population, many farmers are not making a satisfactory income and natural resources - the very bases of the crop, livestock and forest industries - are being damaged and destroyed. There is widespread irreversible damage by wind and water erosion, severe loss of cropping areas through soil salinity and complete destruction of huge areas of arid and semi-arid rangelands through uncontrolled cropping and through overgrazing. Because of these problems there is urgent need to examine priorities in agricultural investment, in agricultural research and extension, and to reassess the major constraints to agricultural production. (See Appendix C).

Despite this gloomy picture, in the generally harsh environments of the Near East and North Africa there is both the ecological possibility and the economic and social practicability for greatly increasing crop and livestock production, providing opportunities for additional employment and generally improving the social and economic wellbeing of the rural and urban communities in the Region. Not only can the crop and pasture-livestock sectors be improved

but also there is a concurrent opportunity for arresting the degradation of natural resources caused by overgrazing of the rangelands, wind and water erosion, desert encroachment, and the uprooting of trees, shrubs and grass for fuel. However, these changes require considerable investment and organization.

There is great need for investment in the general rural infrastructure including transport, telecommunications, electric power and water reticulation; feed production, storage and feedlot fattening units; livestock marketing and slaughtering and cold storage facilities; fertilizers, seeds, agricultural machinery, crop protection, etc. and most importantly in research and training. Yet, priority for investment in agriculture in the Region is apparently inadequate: however, this is a matter of national conscience. Firm administrative actions are required with regard to the control of ploughing on rangelands and steep erodible areas and the control of livestock numbers. Governments should ensure easier interzonal transfer of livestock (by improved transport facilities): however, with more assured feed supplies livestock owners will have to accept a greater degree of control on livestock numbers and there should be a decline in traditional attitudes of carrying extra animals as an insurance against bad seasons and outbreaks of disease. It must be emphasized that with these controls of grazing and livestock numbers it is essential that alternative feed supplies be organized. The potential to provide alternative grazing and/or forage crop and fodder supplies from the traditional rainfed and irrigated croplands is emphasized in earlier sections of this report.

Several of the constraints, including administrative problems, affecting research and development were referred to in the preliminary report (Carter 1977) which is included as Appendix C. Some of these deserve special mention because unless these constraints are eased by Government action neither proper research nor consequent development can occur. Examples of major constraints to research and/or development are given under the following headings.

(b) Agricultural Credit, Production Incentives and Land Tenure

Many farmers of the Region need more encouragement and security. There are needs for policies to upgrade the interests and motivation of the farmers through provision of adequate credit and incentives (including subsidies), guaranteed markets and fair prices. With regard to the latter point, a much better offtake of livestock from the steppe rangelands would result if, for example, Bedouin flock owners were assured fair prices for under-finished lambs (going into a sheep-fattening complex). Credit is needed for purchase of important inputs like seeds and fertilizers if production is to be improved. An excellent example of the impact of new technology, supported by adequate credit facilities and subsidies, in rapidly raising production is provided by the Turkish wheat industry discussed on page 40. However, these advances were in part at the expense of the pasture/rangeland-livestock sector which in Turkey and other countries of the Region has been neglected relative to the cropping sector and this is mainly because the ruminant livestock industry is based on the grazing of common lands.

While security of tenure seems generally assured in the crop lands, excessive fragmentation of holdings is a major constraint to the introduction of new technology e.g. introduction of a forage-crop legume in the rotation, or the *in situ* grazing of pastures or forage crops, or the introduction of varying degrees of mechanization of operations. Governments of the Region face a major challenge to introduce various types of amalgamation of small holdings which could allow mechanization of such operations as land-levelling on irrigated areas. So far as grazing lands are concerned there are very few areas of privately-owned grazing lands in the Region. Most of the grazing lands are common lands - with grossly inadequate controls on intensity and duration of grazing, and ploughing of the steppe and other marginal rangelands. Clearly, Governments must exercise authority over which lands are grazed, and when, and by how many animals. Clearly some type of grazing licence is needed and responsibilities lie with both Government Ministers and Bedouin and other livestock owners. Unless firm and fair administra-

tive actions are taken to prevent further extension of cropping, prevent uprooting of trees, shrubs and grass for fuel and control grazing on the rangelands then no research programme can help the rangelands and both the grazing resources of the rangelands and the livestock industries in the Region are doomed to disaster.

(c) Fencing and Water Supplies

While there are many suggestions of harsh measures to control grazing including the use of barbed-wire fencing these actions will probably be less effective than ensuring an adequate feed supply for a reasonable number of ruminant livestock owned by nomadic and transhumant herdsmen (and not rich merchants). As stated before, there is the ecological possibility and economic practicability to produce this extra feed. Tribes need to be given more responsibility for ensuring maintenance of defined grazing areas as in the past: however, the onus will be on the livestock owners to adopt severe culling programmes to restrict livestock numbers. More control of watering points seems necessary as a means of controlling grazing in the arid and semi-arid rangelands. The tapping of deep underground water in these areas has often been disastrous in that it has encouraged overgrazing. It has had a marked influence on the existing situation in that there are far too many people and livestock in the arid lands e.g. steppe rangelands. Lock-up bores are certainly needed to enforce resting of some grazing areas. Mobile water carts with portable troughing to take the water to livestock to encourage grazing in otherwise under-utilized areas are most worthwhile.

However, all of these measures are quite subsidiary to the prerequisite of growing more livestock feed in the traditional rainfed and irrigated crop lands and maintaining a substantial portion of the livestock permanently in these areas. This will require at least some temporary fencing which can be done cheaply and effectively with roll-up seven-line ringlock fencing<sup>+</sup> and steel fence droppers. Such temporary fencing is needed to help assure proper establishment of pastures and forage crops in some areas - depending on the degree of property fragmentation, the availability of labour for shepherding and whether or not the livestock are yarded at night.

(d) Ensuring Adequate Livestock Feed

There are clear opportunities for greatly increasing the supply of livestock feed by making better use of the traditional fallow areas and other under-producing areas (Table 15). However, to achieve these potentials it will require much organization, as stated previously. Furthermore, in drought-prone areas of the Near East and North Africa it is essential to provide adequate reserves of fodder - principally as hay and straw, also grain. The various livestock co-operatives (Mo'Tassem 1972; Draz 1974a,b) backed up by an increasing number of silo installations and associated feed-preparation plants in Syria provide a useful model for other countries of the Region. Clearly livestock are expensive in the Region and even though feed is usually scarce and expensive there is every justification for preventing losses of animals during drought or seasonal feed shortages. At the same time these reserves of fodder are helping to alleviate the overgrazing of the rangelands.

With regard to the production of extra feed in the Region it is obvious that there has been too much emphasis on use of imported seeds and almost total neglect of local ecotypes. Governments should ensure the formation of efficient pure-seed production and certification organizations to cover both crop and herbage plants. Furthermore, there has been a disproportionate emphasis on testing grasses for rangeland rehabilitation without concurrent actions to enable a reduction and even exclusion of livestock from the arid and semi-arid rangelands. Though it has been traditional to grow small areas of forage-crop legume (usually mixed with barley or other cereal) for grazing or cutting, the idea of making much better use of the fallow areas has not been seriously considered until recently.

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<sup>+</sup> For example Cyclone 7/90/60 ringlock fencing (7 wires, 90cm high, 60cm spacing of vertical stays) is ideal for temporary or permanent fencing.

There is need for an accelerated programme of research and development to greatly increase pasture and forage-crop legumes on the fallow areas of the traditional rainfed and irrigated cropping zones. These legumes offer the best prospects for alleviating livestock feed deficits and consequent reduction of grazing pressure on the rangelands, and concurrent improvement in soil nitrogen levels and consequent cereal yields in the rainfed cereal and irrigated zones.

(e) Conservation of Rangelands

The gross destruction of the rangelands by overgrazing, the uprooting of trees, shrubs and grass for fuel and the uncontrolled spread of cultivation which has been aggravated by mechanized disc ploughing, have been referred to elsewhere. Classic examples are the complete removal of *Pistacia* trees and the uprooting of *Alhagi camelorum* and *Artemisia herba-alba* for fuel in Western Afghanistan. The collection of animal manure for fuel when it is needed as fertilizer in the fields also comes into this problem area. However, this is one area which requires firm administrative action by Governments in the Region. Without firm action no amount of research can help alleviate these problems. Again, with respect to nomadic livestock people, it comes back to the need to provide alternative feed supplies, and alternative fuel supplies. The options to enable more feed supplies have been dealt with adequately, but in terms of providing alternative fuel supplies, there are two possible alternatives. Firstly, the provision and wide distribution of cheap and simple fuel-oil cookers/heaters (as mentioned by Draz 1974b) and/or the provision of bottled gas for the same purpose could save an enormous amount of human destruction of the rangelands and other grazing areas. Secondly, there is a real need for concentrated research and development toward perfecting a cheap and effective solar cooker/heater which could be used for a large part of the year in most countries of the Near East and North Africa.

(f) Training, Research and Extension

In the Near East and North Africa on-job training courses are needed at all levels down to the farmers and field workers but the basic problem lies in the need for more education for most people. The shortage of skilled and experienced personnel at all levels in agriculture is a serious constraint to production despite many training courses for technicians at certificate and diploma level, and university training of both undergraduates and postgraduate students. A common problem in the Region is that many teachers, lecturers and professors at the various training institutions have never travelled beyond Europe. Frequently their agricultural training has been based on European traditions, therefore it is inevitable that present-day students get a disproportionate emphasis on European-type agriculture. While such European visiting, training and teaching may be quite relevant to some enterprises, e.g. viticultural, horticultural and vegetable production, it is certainly not relevant to many of the major field problems of cereal and livestock production in the Region. Therefore, it is important that agricultural education in the Region become more broadly based.

More opportunities need to be provided for agricultural teachers, lecturers, professors, research workers and administrators to see agricultural practices and land use, to participate in training courses, and to undertake postgraduate training in relevant overseas countries e.g. southern Australia, north western United States. Well-organized study tours could do much to broaden knowledge and experience and provide incentive for improvement in agricultural production in the Near East and North Africa. At the same time relevant short courses in the soil, plant and animal sciences given in the Region by visiting professors and agricultural research scientists could greatly help to broaden the interests of participants and help improve the quality and relevance of agricultural research: there are too many examples of research which is irrelevant to existing problems in the Region. In brief, there is a clear need to develop linkages with relevant ecological zones and place less emphasis on countries in close geographical proximity.

Agricultural research in the Region should be confined to relevant and urgent production research amenable to both statistical and economic analysis. With a complete and reliable research base then extension information becomes much more acceptable and changes in agricultural practices or systems of farming achieved more rapidly. However, it must be clearly recognized that with a better educated farming community, most decisions (e.g. date of sowing medic or wheat) must be made by the farmer (or manager) on the spot because he knows the local conditions of soils and weather and the associated risks of sowing early, sowing late, etc. No amount of extension can replace the need for local decision-making.

The training, research and extension programme of the Cereals Project in Algeria is an excellent example of a co-operative effort by national (MARA), bilateral (CIMMYT, CCCE) and multilateral (FAO/UNDP) agencies. The research and training programmes offered by CIMMYT in Mexico and training programmes organized by the FAO Field Food Crops Project inside and outside the Region are greatly assisting in many aspects of cereal and food legume production. However, in the Near East and North Africa, cereal production needs integration with livestock production so there is an urgent need for concurrent training programmes in pasture and forage crop production and the integration of crop production and livestock production.

It is most important that carefully selected graduates from the Region be given the opportunity to undertake advanced training (to Masters and Ph.D. levels) at selected overseas Universities in those disciplines of most relevance to increasing both crop and livestock production in the Region. These persons could then be expected to lead research groups in areas such as pasture ecology and production, pasture management and utilization, rangeland ecology and management, fodder conservation and supplementary feeding, livestock production, tillage practice and soil conservation, soil fertility and fertilizer practice, plant pathology and nematology, entomology, and weed control. Education and training (including postgraduate studies) in relevant aspects of animal production in developing countries has been seriously neglected (McClymont and McDonald 1972; Mohadevan 1973): certainly this needs urgent attention in the Near East and North Africa.

With regard to shortages of trained research leaders, it is quite clear that in all nine countries visited there could be great mutual advantage by closer liaison between Government Ministries and Faculties of Agriculture (including animal production), Veterinary Science, Natural Resources, etc., within the Universities to make collective use of the best talents available to solve urgent problems of agricultural research. This provides opportunity for the University staff members to undertake relevant research with their students and to assist in meeting deficits in trained agricultural scientists in the various Ministries of Agriculture. There is a clear need for development of joint Ministry of Agriculture - University research groups. These comments do not imply that there is no collaboration at present: certainly there is, for example in Algeria, Tunisia and Turkey but there is need for much more co-ordination of effort.

One very serious constraint to effective and relevant site-specific agricultural research is the fact that within the various Ministries of Agriculture and the Universities there is a general shortage of transport, insufficient salary and inadequate daily living allowance to either allow or encourage relevant field research. Even in Turkey which is so much better off in terms of trained research workers than many of the Arab countries, the lack of vehicles seriously curtails field research e.g. in the Faculty of Agriculture of the University of Ankara. Similarly in Iran, with so many resources in terms of physical facilities for research, the daily living allowance for research workers, drivers and others, is quite inadequate to meet costs of meals and overnight accommodation when away from home. The situation in Afghanistan is even worse: trained research workers have completely inadequate transport and a grossly inadequate daily living allowance when away from headquarters - and home. These problems are major disincentives

to undertaking relevant site-specific field research. If a researcher is going to be financially worse off by leaving headquarters - assuming that he can find a vehicle - then it is small wonder that so many of the rural areas are quite inadequately known, administered and researched in the Near East-North African Region: and it is little wonder that significant numbers of potential leaders in agricultural research and administration are being lost in the 'brain drain' from the Region. With regard to extension workers the situation is equally as bad and generally worse in the countries of the Region. Better-trained, better-paid and more-mobile extension workers are needed for working with farmers on their farms. While some countries lack the equipment and facilities for doing relevant research these are less of a constraint than the factors mentioned above. Furthermore, there is need for more decentralization of authority in research and extension administration.

In summary, while it is difficult to generalise over the whole Region, there are several common problems which can be alleviated only by the various Governments. Firstly, there is a relatively inadequate investment in agriculture and within this agricultural investment there is a gross neglect of the pasture/rangeland-livestock sector: as stated previously, the priorities for investment are matters of national conscience and it is a case of 'swords vs. plough shares'. Major administrative action is required in most countries to provide:

- (i) agricultural credit, production incentives or subsidies for the farmers;
- (ii) security of land tenure but possible amalgamation of fragmented farms;
- (iii) the provision of more livestock feed in the traditional rainfed and irrigated croplands with associated fencing and water points as required;
- (iv) the concurrent reduction of livestock and population in the rangelands to allow rehabilitation and conservation of these rangelands; and (v) an improved infrastructure for training, research and extension. Without these administrative actions the various lines of research, detailed in the previous section - 2, are going to have inadequate impact on agricultural production, protection of natural resources or improving the social and economic wellbeing of the people of the Region.

#### 4. Implications for ICARDA

##### (a) Research Activities

The mandate for ICARDA covering the broad objectives of the improvement of basic food crops (especially barley, broad beans and lentils), the development of new farming systems, and the assistance with research and training in the Region has been outlined in Appendix C. However, it is quite clear that the widespread degradation of natural resources caused by uncontrolled cultivation, uncontrolled grazing, and uncontrolled uprooting of trees, shrubs and grass for fuel in many areas (especially semi-arid and arid rangelands) of the Region has far wider implications than generally appreciated. While the main solution to this problem lies in providing alternative livestock feed supplies through research leading to the widespread use of leguminous pastures and forage crops on fallow land in the traditional rainfed and irrigated cropping zones (Table 15), thus allowing a reduction of both human population and livestock in the arid rangeland areas, this may not be sufficient. ICARDA may well need to become involved in the research and training component of the conservation of natural resources particularly land management in the broader sense, especially matters like land use capability planning, watershed management and erosion control. Hopefully, ICARDA will play a leading role in the promotion of research related to the ecology, production, management and utilization of pastures and forage crops, crop-livestock integration, and associated training programmes in the Near East and North African countries. ICARDA has the difficult, but important, task of assisting in the improvement of crop and livestock production and concurrently assisting programmes designed to stop and repair damage to the natural resource base of these agricultural industries. But these aspects should be considered two interrelated components of a major interzonal system. Therefore, it is a

matter of high priority that ICARDA should support positive actions which are designed to not only research and demonstrate the feasibility of growing more leguminous pastures and forage crops in the traditional rainfed and irrigated cropping zones but also those moves to assist ruminant livestock (especially sheep) management and production in the Region. Furthermore, in these pasture-livestock research activities it is important that ICARDA operate in all four major land use zones to help provide unequivocal evidence for policy-makers on the potential interzonal complementarities of the arid and semi-arid rangelands, the rainfed cereal zones, the humid pasture zones and the irrigated zones of the Region.

The foregoing suggestions concerning the desirability of ICARDA becoming involved in research on conservation of natural resources and in ruminant livestock management and production arise from the list of eleven interrelated priority research topics given on pages 61-65. This is not to imply that ICARDA should necessarily become actively involved in all of these research topics or with equal emphasis and priority. Clearly, the collection and analysis of agrometeorological data is a prerequisite for effective and relevant field research in the Region. Likewise, tillage methods and tillage practice, methods of pasture and forage crop establishment, rotation experiments and the general programme of plant introduction and evaluation of local ecotypes have relevance to both the cereal and grain legume improvement programmes of ICARDA just as they do to any pasture-livestock improvement programme. The research topics related to rangeland ecology, management and production; potential for improvement in the humid pasture zones; and the potential role of salt-tolerant pasture and forage-crop species, while directly affecting the potential for livestock feed supply, have an indirect effect through potential damage to adjacent cropping lands and therefore must be the concern of ICARDA in its work on farming systems.

The last three research topics are specifically related to improving the output/head and output/hectare of livestock products. However, topics such as grazing management and utilization of pasture and forage-crop species have a direct bearing on weed populations in the proposed integrated ley-farming system so once more this is of direct relevance to the mandate of ICARDA. Likewise fodder conservation can be a useful aid to weed control in good seasons, or where inadequate numbers of livestock are available for critically-timed grazing of newly-established pastures and forage crops, and again this is an important component of any farming system involving crop-livestock integration in the Region. Finally, with regard to the management and productivity of the sheep, goat, cattle and camel flocks and herds of the Region, the crucial need to increase the rate of offtake of young animals and restrict the numbers of adult stock on the rangelands, is closely related to provision of alternative grazing on the traditional rainfed and irrigated crop areas and/or to the availability of guaranteed supplies of supplementary feed, or access to a feed-lot system. These are directly concerned with ICARDA programmes: thus all eleven of the proposed research priorities for the Region are directly or indirectly related to existing or proposed research programmes of ICARDA.

With specific reference to the involvement of ICARDA in animal research it is suggested that direct research be confined to sheep because sheep are the most important livestock in the Region. Both the Syrian and Iranian centres of ICARDA should have sheep-breeding flocks based on c. 500 breeding ewes to research and demonstrate aspects of selection and feeding and to ensure the availability of even lines of sheep for necessary grazing and/or supplementary feeding experiments under field conditions. Good sheep-handling facilities (yards, drafting race, clockface sheep-weighing scales and cage, sheep dip, shearing shed, etc) will be needed on each of the main ICARDA field centres. Sheep will also be required for pen-feeding experiments involving the evaluation of various pastures and forage crops, and feed-mixes. It is suggested that the animal house experimentation undertaken by ICARDA need not go beyond the level of *in vivo* digestibility with supporting laboratory facilities for determining *in vitro* digestibility. The same digestibility pens and faecal-collection harness can be used for any studies on seed ingestion/seed throughput involving various pasture and forage-crop legumes.

For the *in vivo* digestibility studies an animal house (c. 300 square metres) and associated cold room and dehydrator facilities are essential. If carefully planned, these cold room and dehydrator units should also serve the needs of the pasture and forage crop research programme. Initially, two contiguous cold rooms of c. 15 cubic metre capacity and two contiguous forced-draught dehydrators of c. 4 cubic metre capacity should serve the pasture/animal research programmes at each of the main ICARDA centres.

Because of the importance of pasture and forage-crop legumes in the nitrogen economy of the cropping soils, quite apart from the potential of legumes to form the basis of extra livestock feed, ICARDA research on pasture and forage-crop species should concentrate very heavily on legumes, especially the potential role of both annual and perennial legumes in farming systems. There is no justification for ICARDA to become actively involved in screening and evaluation of grasses and other species for range regeneration. However, there is merit in ICARDA supporting a minor research programme on evaluating species of high-producing warm-season grasses for growing as special-purpose forage crops in some irrigated areas. While it will be essential for ICARDA to develop substantial nursery, screening and early-evaluation areas for the major programme on annual and perennial pasture and forage-crop legumes it should be emphasized that much of this research data will be very site-specific so that it would be a mistake to establish a huge area of genotypes at the main ICARDA research centres. On the other hand, an adequate collection embracing the main range of characters for the various commercialized pasture and forage-crop legumes used in the Region should be maintained. Of course, there will need to be a well-organized seed-store to allow ready access to a range of germ-plasm. In this matter it is clear that ICARDA needs to liaise with various Ministries and Universities which maintain collections of pasture and forage-crop legumes in the Region and also such groups as the United States Department of Agriculture (USA) and the Parafield Plant Introduction Centre in South Australia, this latter Centre having the largest world collection of germ-plasm of the annual species of *Medicago*.

There is a clear need for ICARDA to make use of existing national and international research being done in the Region and ICARDA has an opportunity to facilitate interchange of materials and information and to generally assist in co-ordination of research and in some cases to improve the relevance and quality of the research. There are many excellent groups of trained agricultural scientists in the Region but some need encouragement and guidance also financial assistance. Unfortunately there are some signs of competition between departments within national Ministries of Agriculture, competition between Ministries, and competition between Ministries of Agriculture and Faculties of Agriculture of the Universities of the Region. Certainly some competition is healthy but not when it leads to overlap and duplication of effort when there is so much applied agricultural research needed in the Region. As stated before, there is considerable trained agricultural potential in the Universities and much could be done by staff and students of the Universities joining forces with relevant Ministry of Agriculture groups to solve some of the local problems. In this respect ICARDA may be able to help activate some of this much-needed, co-operative, site-specific research by identifying and financially-assisting dedicated research groups within the Universities. Involvement of University staff in relevant local research problems would assist the quality of teaching and also the research outlook of both staff and students. Some projects could meet undergraduate and postgraduate thesis requirements at local Universities in the Region. As many of these projects need to be replicated in time and space, this also suits thesis requirements. Sponsorship of joint University-Ministry of Agriculture research groups would be a very sound investment by ICARDA and/or the Government of the country.

Good examples of the type of valuable co-operative research that could well be done by a combined team of University staff and students and Ministry of Agriculture staff are research topics (b) (The Ecology and Production of Existing Pasture and Forage-Crop Species) on page 61 and (h) (Rangeland Ecology, Management

and Utilization) on page 64. Both of these research topics not only involve agricultural science students but also those trained in pure plant ecology, watershed management and other disciplines. Similarly, soil science students should be involved in these research topics. Topic (g) (Salt-Tolerant Pasture and Forage-Crop Species) is suited to students of agronomy, plant ecology and soil chemistry, while the broader issues of the mounting salinity problem in many rainfed and irrigated areas of the Region lends itself to a multi-disciplinary attack by agronomists, engineers and soil scientists. Clearly, ICARDA cannot undertake extensive research programmes in all these areas but it can play a vital role in stimulating inter-disciplinary discussion and helping to co-ordinate research on these important problems of the Region. Frequently it is not a shortage of money or physical facilities that limits agricultural research in the Region. What is limiting - and often the major constraint - is the shortage of adequately-trained team leaders, and any semblance of stability in staffing.

#### (b) Training Activities

While ICARDA has some clear responsibilities for training in the Region, hopefully sponsorship of training will extend beyond the Region. This training is needed at all levels: some can be done in the local fields, some at the main ICARDA research centres or sub-stations or elsewhere in the Region, and some in relevant ecological environments in foreign countries. However, very specialized advanced postgraduate training is a common cause of discontent and consequent loss of trained researchers through the 'brain drain'. The fact that administrators of Government Departments are often young appointees, frequently with inadequate experience and knowledge of the problems and priorities in the agricultural sector, aggravates the problems of agricultural development. Too frequently, political expediency takes precedence over logical agricultural development based on sound socio-economic and ecological principles. Therefore, in promoting change in attitudes to science and technology with the object of assisting development of the Region, the most urgent need is to get high-level Government and University administrators to relevant foreign countries to see at first hand the scope for agricultural (and other) development and the potential for development in their own countries. Senior administrators need to be convinced of the need for change because they have far more political influence than undergraduate or postgraduate students who may be returning from overseas training.

Farmers, technicians, etc., are best trained in their home countries but research and extension workers, University academic staff, and administrators in general from the Region, would greatly profit from training in relevant overseas countries (e.g. western United States, southern Australia) and at home. University Faculty exchange systems have much merit but there is often a language problem. However, it is better to have a person with a useful message needing translation than someone with the language but no useful information to impart.

The bilateral training agreements between various foreign countries and the countries of the Near East and North Africa tends to perpetuate the long-standing arrangement in which a disproportionate amount of agricultural training is done in the European Zone. This is not to imply that in many professions and in many of the disciplines in the agricultural sciences, such training is not entirely proper and relevant. However, in many fields of training, e.g. crop and pasture agronomy, rangeland ecology and livestock husbandry and management, study in Europe may be far less useful than in some ecologically analogous regions in the United States or southern Australia. However, although the United States Government provides for trainees from the Region, at present the only training opportunities available to people from the Near East or North Africa to go to Australia are through:

(i) a limited number of FAO Fellowships to study various aspects of agriculture for periods of 6-12 months; (ii) an occasional postgraduate studentship funded privately or by such groups as FAO, CIMMYT or IRRI; and (iii) some FAO-sponsored training positions at Roseworthy Agricultural College for the Graduate Diploma in Agriculture as mentioned on page 58. Hopefully the Australian Government and ICARDA can finance postgraduate students from the Near East and North Africa to study at ecologically-relevant Faculties of Agriculture in southern Australia.

## V. CONCLUSIONS AND RECOMMENDATIONS

1. The main conclusion reached from this further 20,000 km of road travel in North Africa and the Near East is that the outstanding rural problem of the Region is the disastrous deterioration of natural resources, viz:

- (i) the decline in the area of useful arable land through erosion caused by reckless cultivation, and through soil salinity;
- (ii) the decline in the area of rangeland through uncontrolled cultivation, consequent devastation and desert encroachment; and
- (iii) the decline in rangeland productivity through overgrazing and consequent denudation aggravated by removal of grass, shrubs and trees for fuel.

Of course these three components of the degradation of natural resources are closely interrelated and result from the rapid rise in both human population and livestock numbers, especially in the past 30 years.

2. Having regard to the problems of the widespread and disastrous deterioration of natural resources and the rapid increase in population there is an inadequate level of national investment in agriculture and a gross neglect of the pasture/rangeland-livestock sector. Until agriculture receives a higher percentage of national investment then deficits in human food and livestock feed, and the consequent devastation of both crop and grazing lands, is likely to continue.

3. Despite this gloomy picture there is clear evidence of a potential for greatly increasing livestock feed by the widespread sowing of pasture and forage-crop legumes on fallow lands in the traditional rainfed and irrigated cropping areas and for improvement in the levels of soil nitrogen and yields of subsequent cereal crops. There is also considerable potential to improve pasture productivity through use of phosphatic fertilizer in the humid zones of the Region.

4. In the nine countries (Algeria, Tunisia, Libya, Jordan, Syria, Iraq, Turkey, Iran and Afghanistan) considered in this report it is realistic to establish 23 M ha of pasture and forage-crop legumes on the existing 30 M ha of fallow (which is mainly in the rainfed cereal zone). Directly or indirectly this area of legumes should increase livestock feed supply by 80.6 M t DM/annum. A further 42.7 M t DM/annum is possible from the humid and irrigated zones. This total increase of 123.3 M t DM would suffice for 154 M ewe equivalents.

5. Using a conservative estimate of 60 kg N/ha/annum as the mean nitrogen increment this 23 M ha of pasture and forage-crop legumes would give a total nitrogen increment of 1.39 M t which is 65% higher than the existing total fertilizer nitrogen input for the nine countries mentioned above. Furthermore, the leguminous pastures and forage crops should increase the levels of soil organic matter, and improve soil structure and infiltration. If properly managed, a dense stand of annual legumes will control weeds through competition and through livestock grazing (or mowing). There should also be substantial increases in cereal yields as a consequence of the improved soil fertility.

6. The clear implication from the potential to greatly increase the production of livestock feed supplies and greatly improve the levels of soil nitrogen by the sowing of pasture and forage-crop legumes on 23 M ha of the 30 M ha of existing fallow in these nine countries is that the grazing pressure on the rangelands can be greatly reduced, thus allowing slow rehabilitation of these areas.

7. To achieve these potential increases through use of legumes in rotations, countries of the Region will have to make substantial investment in:

- (i) fertilizers - especially soluble phosphatic fertilizer;
- (ii) seeds - predominantly pasture and forage-crop legumes;
- (iii) agricultural machinery - need well-designed and strongly-made tillage and sowing implements incorporating the stump-jump principle and of the trailing type with large wheels, to allow rapid, shallow, tillage and sowing operations and to level the seedbed. Implement size will vary with farm size;

- (iv) crop and pasture protection - equipment and materials are both needed;
- (v) fencing and water supplies - including temporary roll-up fencing of the Cyclone ringlock type and mobile water tankers; and
- (vi) training - needed at all levels for crop and pasture-livestock production: e.g. machinery operators, farm managers and research and extension personnel.

However, these investment costs should be soon recouped through greater production of livestock feed, consequent increase in livestock production and stabilization of grazing resources; greater nitrogen fixation by legumes (thus saving fertilizer nitrogen inputs) and increased cereal production; reduced costs of tillage and weed control, decreased soil erosion and stabilization of cropland resources.

8. Because of the long-term nature of investment in pasture improvement and development of flocks and herds in the Region, adequate production incentives must be provided through Government policies on agricultural credit, on prices of cereal and livestock products and on security of land tenure.

9. While there are many urgent measures that can be taken to ensure success of a legume-cereal rotation in the Region (e.g. by reducing depth of tillage to a maximum of 8-10 cm, dry-sowing of annual legumes e.g. medics, and using more superphosphate), there is need for an accelerated research programme on the ecology, production, management and utilization of leguminous pastures and forage crops and on consequent livestock production to complement the research programmes on cereal production.

10. There is need to ensure that agricultural graduates and diplomates receive a broader-based training more suited to tackling the problems of crop and pasture production, pasture-livestock management and crop-livestock integration. Suitable candidates for higher degrees should be sent for postgraduate studies related to production research in ecologically-relevant overseas Faculties of Agriculture.

11. In addition to its responsibilities for cereal improvement and food legume improvement in the Region, ICARDA should play a leading role in the promotion of research related to the ecology, production, management and utilization of pastures and forage crops, crop-livestock integration, and associated training programmes in the Near East-North African Region also other relevant countries.

12. Because of the potential interzonal complementarities with regard to crop-livestock integration it is essential that, in evaluating potential farming systems for the Region, ICARDA be involved in all four major land use zones: namely the arid and semi-arid rangelands, the rainfed cereal zones, the humid pasture zones and the irrigated zones of the various countries of the Region.

13. There is no shortage of local ecotypes of a great range of potentially-useful pasture and forage-crop legume species throughout the Near East and North African Region. However, the virtual absence of a seed industry for herbage plants has greatly restricted exploitation of many ecotypes which include annual and perennial *Medicago* spp. and *Trifolium* spp., *Onobrychis* spp. *Vicia* spp. and *Trigonella* spp. There is an urgent need for plant collection, correct identification, evaluation, and seed increase of promising ecotypes.

14. There is considerable merit in ICARDA involving such groups as the Plant Introduction Section of the South Australian Department of Agriculture and Fisheries in a co-operative effort to assist in collection and evaluation of pasture and forage-crop legumes. Later, such groups as the South Australian Seed-growers Cooperative could greatly assist in seed multiplication of selected species or cultivars. Of course the main testing would have to be done at relevant sites in the Near East or North Africa. However, until such time as seed from superior local ecotypes is available commercially, there is definite need and an important role for commercial cultivars of pasture and forage-crop legumes from such places as southern Australia, Europe and North America.

15. Research on pastures and forage crops in traditional rainfed cereal zones and irrigated zones should concentrate almost wholly on legumes as livestock feed and for soil improvement. Apart from some scope for warm-season grasses for forage crops, any research on pasture grasses should be confined to the potential for non-arable sites or semi-arid rangelands. In the humid areas the emphasis should be on oversowing legumes and use of phosphatic fertilizers.

16. Unless for a very specific purpose (e.g. incorporating pest or disease tolerance or resistance into an existing outstanding cultivar), there is no justification for embarking on an expensive breeding programme with pasture and forage-crop legumes until the huge range of genetic variability within the indigenous species and local ecotypes in the Region is thoroughly explored and at least partially evaluated. Any new legume species (or cultivars) proposed for grazed pasture or forage crop must be evaluated in part under grazing by sheep to assess response to defoliation and treading and also to check for toxic principles (though the latter can best be done under pen-feeding conditions).

17. The soil/plant/animal/socio-economic complex will dictate existing and potential new farming systems. Sheep are the most important livestock in the Region: hence sheep should form the basis of the ICARDA-supported livestock research in the Region. As the main constraint to livestock production is feed supply, if systems can be evolved to provide adequate feed for sheep then there should be sufficient feed for alternative livestock. There is no justification for ICARDA undertaking detailed research on camels, cattle or goats in the Region. Many dairy herds in the Region are relatively isolated from the environment.

18. Fodder conservation and supplementary feeding will continue as an integral part of livestock production in the Region. Research on the most efficient use of locally-grown feeds and the blending of appropriate feed mixes requires that both the Syrian and Iranian Centres of ICARDA should have sheep breeding flocks based on c.500 breeding ewes to ensure the availability of even lines of sheep for experiments. In addition to adequate winter housing, good sheep-handling facilities (yards, drafting race, clockface-type sheep-weighing scales and cage, sheep dip, shearing shed, etc.) are required. Also it will be essential to have a separate animal house with *in vivo* digestibility pens for harnessed sheep (faecal collection) plus cold storage and dehydration facilities. Furthermore, *in vitro* laboratory digestibility equipment will be required.

19. The gross neglect of the pasture/rangeland-livestock sector (based mainly on common lands) relative to the administrative and research attention to the cropping areas in the Region is a matter for great concern. Research on pasture and forage-crop legumes will have limited impact without concurrent actions designed to preserve and/or improve the common grazing lands. The rehabilitation of common grazing lands will require a delicate blend of political, social, economic and technical expertise, and site-specific research data will be needed to assist in decision-making. Any consideration of farming systems by ICARDA must necessarily involve the above problems. Hence it will be most important for ICARDA to work closely with existing national research programmes. In most countries of the Region there are research groups who are concerned with improvement of the pasture/rangeland-livestock sector. These groups include enthusiastic, young, well-trained staff, but they need encouragement, guidance, and in some cases financial assistance.

20. The long-term prospects for agricultural development in the Near East and North Africa depend largely on the supply of local expertise. But first it is necessary to convince policy-makers of the need for change: they should be encouraged to visit relevant overseas countries to see the opportunities for development in analogous ecological areas. Finally, it is most important that selected graduate students be given the opportunity to study for higher degrees in the broad fields of crop agronomy, pasture agronomy and animal production at ecologically-relevant Faculties of Agriculture outside of the Region.

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#### Notes

- (1) The foregoing list of references includes several that were used only in the preliminary report, which is included as Appendix C.
- (2) While the references are not claimed to be complete they do permit the reader to gain a reasonable perspective of the existing state of agriculture and related socio-economic problems in the Near East and North African Region. Further, the references allow comparison of this Region with the Mediterranean-type environments of southern Australia and highlight the climatic and edaphic analogies and the potential similarities in land use of these widely-separated regions.

## APPENDICES

APPENDIX A

APPENDIX TABLES 1-8

(Pages 89-95)

APPENDIX TABLE 1

## LIVESTOCK STATISTICS FOR NINE COUNTRIES OF THE NEAR EAST - NORTH AFRICAN REGION

	(1) Horses Thousands		(4) Cattle Thousands		(7) Pigs Thousands	
	(2) Mules "		(5) Buffaloes "		(8) Sheep "	
	(3) Asses "		(6) Camels "		(9) Goats "	
	1961-65	1976	1961-65	1976	1961-65	1976
Afghanistan	(1) 279	370	(4) 3230	3676	(7) -	-
	(2) 23	27	(5) 22	37	(8) 17940	18000
	(3) 1121	1250	(6) 318	290	(9) 3757	2350
Algeria	(1) 121	156	(4) 810	1281	(7) 34	4
	(2) 153	205	(5) -	-	(8) 6180	8886
	(3) 266	439	(6) 165	157	(9) 1950	2400
Iran	(1) 449	350	(4) 5060	6650	(7) 53	68
	(2) 130	120	(5) 247	130	(8) 30410	35300
	(3) 2041	1800	(6) 234	60	(9) 13006	14300
Iraq	(1) 159	83	(4) 1531	2081	(7) -	-
	(2) 95	10	(5) 238	175	(8) 10138	8400 <sup>+</sup>
	(3) 560	607	(6) 200	330	(9) 2209	2584
Jordan	(1) 6	2	(4) 61	35	(7) -	-
	(2) 15	8	(5) -	-	(8) 752	818
	(3) 78	38	(6) 17	18	(9) 592	474
Libyan A.R.	(1) 31	15	(4) 106	123	(7) -	-
	(2) 1	-	(5) -	-	(8) 1378	3360
	(3) 117	73	(6) 266	120	(9) 1281	1125
Syrian A.R.	(1) 67	55	(4) 454	555	(7) -	1
	(2) 68	49	(5) 2	2	(8) 4035	6200
	(3) 195	240	(6) 11	6	(9) 668	750
Tunisia	(1) 81	106	(4) 562	880	(7) 4	3
	(2) 51	66	(5) -	-	(8) 2804	3526
	(3) 158	195	(6) 158	195	(9) 525	900
Turkey	(1) 1247	870	(4) 12621	13751	(7) 11	16
	(2) 197	300	(5) 1162	1051	(8) 32863	41367
	(3) 1899	1476	(6) 54	18	(9) 22665	18763

Source: FAO Production Yearbook Vol.30, 1976.

<sup>+</sup> This figure compares with figures of 15,500 or more in the previous three years (See Table 10).

APPENDIX TABLE 2

LAND USE AND PRODUCTION IN THE AUSTRALIAN CEREAL-LIVESTOCK ZONE  
(Average values per property by States and for Australia, 1969-70)

Item	Unit	N.S.W.	Vic.	Qld.	S.A.	W.A.	Wheat Sheep Zone
Wheat	Hectares	179	159	77	128	205	167
Oats	"	29	30	40	27	72	36
Barley	"	15	21	6	51	24	23
Other crops	"	10	trace	23	4	6	7
<u>Total Crops:</u>	Hectares	233	210	145	210	308	234
Fallow	Hectares	12	37	2	19	22	20
Improved pasture	"	357	409	46	362	620	403
Native pasture	"	307	162	1,240	248	246	285
Area not used	"	20	10	51	57	81	36
<u>Total area:</u>	Hectares	929	828	1,484	897	1,277	978
Sheep carried*	No.	1,785	1,276	1,522	1,200	2,259	1,649
Sheep & lambs shorn "	"	1,968	1,409	1,514	1,196	2,574	1,805
Wool - produced	Kg.	8,408	6,528	6,575	5,973	9,689	7,755
- cut/head	Kg.	4.3	4.6	4.3	5.0	3.8	4.3
- price/kg	Cents	81.8	80.4	85.1	75.6	83.0	81.1
Lambing percent	%	76.3	88.1	82.0	77.1	66.0	75.9
Lambs marked	No.	763	518	262	432	728	634
Cattle carried*	No.	98	25	92	13	15	54
Sheep equivalents <u>carried**</u>	No.	2,569	1,477	2,261	1,306	2,380	2,084
Cereal grain produced:							
Wheat (1)	Tonnes	250	259	58	163	129	211
Oats (2)	"	15.3	26.0	1.3	13.9	28.8	19.1
Barley (3)	"	13.6	15.1	6.7	67.7	17.2	23.6
<u>Total (1)(2)(3)</u>	Tonnes	278.9	300.1	66.0	244.6	175.0	253.7
Superphosphate used on:-							
Crops	Tonnes	11.1	15.1	0.4	26.9	36.7	18.6
Sown pasture	"	8.1	7.5	3.1	11.9	35.5	13.0
Native pasture	"	1.3	0.4	—	1.9	1.6	1.2
<u>Total</u>	Tonnes	20.5	23.1	3.6	40.7	73.8	32.8

\* Average of numbers at beginning and end of year.

\*\* Sheep carried plus eight times the number of cattle carried.

Source: Australian Sheep Industry Survey 1967-68 to  
1970-71, Tables 29, 32.

Bureau of Agricultural Economics, 1973.

Note: This table is from Carter (1975b).

APPENDIX TABLE 3

## SOME COMPARATIVE CLIMATIC DATA FOR MEDICAGO AREAS

Algeria					Southern Australia				
Station	Altitude (m)	Precip. $\phi$ (mm)	Max. Temp. * (°C)	Min. Temp. $\nabla$ (°C)	Station	Altitude (m)	Precip. (mm)	Max. Temp. (°C)	Min. Temp. (°C)
Alger (Port)	5	647	30.9	9.8	Adelaide S.Aust.	43	536	29.3	7.4
Annaba	58	674	29.8	7.9	Cleve "	198	398	27.6	6.8
Berrouaghia	930	593	34.2	0.6	Georgetown "	273	448	31.1	4.1
Bouira	531	523	36.0	1.9	Kapunda "	245	491	29.1	5.3
Constantine	660	523	32.8	2.9	Kyancutta "	65	329	32.6	4.8
El Asnam	112	396	38.2	3.5	Lameroo "	99	381	30.6	4.1
El Harrach	48	657	30.9	6.4	Pt. Pirie "	5	330	31.8	7.4
Guelma	270	609	35.4	4.2	Roseworthy "	63	420	29.7	5.8
Mascara	583	456	34.8	4.1	Yongala "	512	370	29.9	2.3
Medea	912	826	32.2	3.2	Streaky Bay "	13	371	29.3	8.3
Mostaganem	111	425	28.4	9.0	Dimboola Vic.	111	407	29.9	3.4
Oran (Port)	3	381	28.7	9.1	Kerang "	78	363	30.9	3.9
Saida	872	424	36.2	2.6	Murrayville "	58	320	31.0	2.7
Setif	1081	457	32.5	0.4	Swan Hill "	70	332	31.7	3.9
Sidi-Bel-Abbes	486	414	33.2	1.9	Walpeup "	107	317	31.2	4.7
Souk Ahras	655	727	33.4	1.4	Condobolin N.S.W.	199	409	34.7	3.4
Tebessa	863	343	34.8	1.9	Deniliquin "	95	393	31.1	4.4
Tiaret	1023	615	33.0	1.7	Forbes "	238	489	33.3	3.5
Tizi Ouzou	230	914	35.5	5.4	Temora "	292	473	30.6	1.9
Tlemcen	810	688	31.4	5.8	Trangie "	219	415	33.7	2.7

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 $\phi$  Mean annual precipitation

\* Mean maximum temperature for the hottest summer month i.e. July in Algeria and January in southern Australia

 $\nabla$  Mean minimum temperature for the coldest winter month i.e. January in Algeria and July in southern Australia

Sources: Climatic Averages Australia, Bureau of Meteorology, 1956  
Bounaga, Chaumont and Paquin (1971); Le Houerou (1971)

Note: This table is from Carter (1974b, 1975a)

## APPENDIX TABLE 4

SOME SPECIES COMMON IN CEREAL ZONES AND ADJACENT HIGHER-RAINFALL AREAS  
OF ALGERIA AND SOUTH AUSTRALIA

---

Adonis annua
Asphodelus fistulosus
Avena barbata, A. fatua, A. sterilis
Brassica tournefortii
Bromus diandrus, B. hordeaceus, B. mollis, B. unioloides
Capsella bursa-pastoris
Carrichtera annua
Chenopodium album
Diplotaxis tenuifolia
Echium italicum, E. lycopsis
Fumaria officinalis
Hordeum leporinum, H. marinum
Hypochoeris glabra, H. radicata
Lolium multiflorum, L. perenne, L. rigidum, L. temulentum
Malva parviflora
Marrubium vulgare
Medicago minima, M. polymorpha, M. scutellata, M. truncatula
Melilotus indica, M. officinalis
Onopordum acaulon
Oxalis pes-caprae
Papaver hybridum, P. rhoeas
Phalaris minor, Ph. tuberosa
Plantago lanceolata, P. major
Poa annua, P. pratensis
Raphanus raphanistrum
Rapistrum rugosum
Reseda alba, R. lutea, R. luteola
Salsola kali
Silene vulgaris
Silybum marianum
Sinapsis arvensis
Sisymbrium officinale, S. orientale
Trifolium fragiferum, T. glomeratum, T. resupinatum, T. subterraneum and Urtica dioica, U. urens T. tomentosum

---

Source : Carter (1974b, 1975a)

Note : With few exceptions (e.g. Oxalis pes-caprae) the above species are native to Algeria. However, none are native to Australia.

## APPENDIX TABLE 5

## SOME COMPARATIVE AGRICULTURAL STATISTICS

	Algeria	South Australia
<u>Total Area (ha)</u>	237,556,000	98,400,000
<u>Distribution of Land By Rainfall</u>		
> 600 mm	5,081,000 <sup>(1)</sup>	1,082,000
500-600 mm	1,756,000	2,165,000
400-500 mm	4,538,000	4,428,000
300-400 mm	7,558,000	3,051,000
< 300 mm	218,623,000	87,674,000
<u>Land Used for Agriculture (ha) (1971/72)</u>	42,449,000	65,146,000
Cereals for grain (ha)	3,228,000 <sup>(2)</sup>	2,041,000
Other annual crops <sup>(3)</sup> (ha)	313,000	181,000
Fallow (ha)	2,707,000	402,000
Vineyards (ha)	300,000	29,000
Orchards and Vegetables (ha)	252,000	27,000
Pasture (ha)	35,000	3,194,000
Rangeland (ha)	34,345,000 <sup>(4)</sup>	59,272,000
Unproductive farm lands (ha)	1,269,000	tr
<u>Superphosphate Used (Means 1966/67-1971/72)</u>		
Crops (tonnes P <sub>2</sub> O <sub>5</sub> )	31,360	60,968
Pastures (tonnes P <sub>2</sub> O <sub>5</sub> )	tr	59,444
<u>Cereal Production (Means 1961-72)</u>		
Wheat harvested (ha)	2,035,200	1,165,600
Wheat yield (kg/ha)	624	1,139
Barley harvested (ha)	728,900	561,000
Barley yield (kg/ha)	610	1,131
<u>Livestock (Mean head 1970-72)</u>		
Sheep	8,357,000	18,961,000
Cattle	864,000	1,239,000

(1) Includes 1,335,000 ha with slope > 25%

(2) Includes c. 1 million ha in marginal steppe

(3) Includes cereals for hay and green forage crops

(4) Includes c. 20 million ha of steppe

Sources: Statistique Agricole (MARA) and Algeria in Numbers, 1962-72.

Statistical Register of South Australia 1971-72, Commonwealth Bureau Census and Statistics. Note: This table is from Carter (1974b, 1975a).

APPENDIX TABLE 6

## CLIMATIC DATA FROM EASTERN HIGHLANDS OF AUSTRALIA

<u>Northern Tableland Station</u>	<u>Altitude (m)</u>	<u>Precip. <math>\phi</math> (mm)</u>	<u>Max. Temp. * (°C)</u>	<u>Min. Temp. + (°C)</u>
Armidale N.S.W.	1016	736	27.1	1.0
Glen Innes N.S.W.	1073	796	26.9	0.4
Guyra N.S.W.	1320	871	25.3	-0.7
<u>Southern Tableland Station</u>				
Canberra A.C.T.	560	592	27.8	0.7
Cooma N.S.W.	689	479	26.0	-1.0
Crookwell N.S.W.	887	861	26.7	-0.3

$\phi$  Mean annual precipitation

\* Mean maximum temperature for the hottest summer month i.e., January in southern Australia.

+ Mean minimum temperature for the coldest winter month i.e., July " "

Sources: Climatic Averages Australia, Bureau of Meteorology, 1956 and Carter (1974b, 1975a).

APPENDIX TABLE 7

## DOMINANT WEEDS COLLECTED FROM LATE-TILLAGE EXPERIMENT

Ministry of Agriculture Haymana Farm, Haymana, Turkey

June 10, 1977

<u>Scientific Name</u>	<u>Common Name</u>
Bromus tectorum	Downy brome
Camelina microcarpa	Hairy false flax
Camelina sativa	Large-seed false flax
Centaurea depressa	Dark bluebottle
Convolvulus arvensis	Field bindweed
Descurainia sophia	Flixweed
Lamium amplexicaule	Deadnettle
Matricaria sp.	Papatya (Turkish)
Reseda lutea	Cut-leaf mignonette
Sisymbrium altissimum	Jim Hill mustard (Turkey)

Above weeds identified by Ms Nedret Durutan, Ministry of Agriculture, Turkey.

## APPENDIX TABLE 8

## IRANIAN ECOTYPES IN THE PROGRAMME OF PLANT INTRODUCTION AND EVALUATION

GRASSES

<i>Aeluropus littoralis</i>		<i>Festuca sclerophylla</i>	
" <i>repens</i>		" <i>spectabilis</i>	
<i>Agropyron aucheri</i>		" <i>vallosiaca</i>	
" <i>cristatum</i>		<i>Glyceria</i> sp.	+
" <i>elongatum</i>		<i>Hordeum bulbosum</i>	+
" <i>intermedium</i>		" <i>fragile</i>	
" <i>leptourum</i>		" <i>violaceum</i>	
" <i>longearistatum</i>		<i>Koeleria gracilis</i>	+
" <i>tauri</i>		" <i>phleoides</i>	++
" <i>trichophorum</i>		<i>Lasiagrostis caragana</i>	
<i>Alopecurus arundinaceae</i>	+	<i>Lolium perenne</i>	++
" <i>aucheri</i>		<i>Melica inaequiglumis</i>	
" <i>pratensis</i>	++	<i>Oryzopsis holciformis</i>	+
<i>Andropogon ischaemum</i>	+	" <i>molinioides</i>	
<i>Aristida caerulea</i>	+	<i>Pennisetum ciliare</i>	++
" <i>plumosa</i>		" <i>dichotomum</i>	
<i>Arrhenatherum elatius</i>	++	" <i>orientale</i>	
<i>Avena barbata</i>	++	<i>Phalaris canariensis</i>	++
<i>Brachypodium pinnatum</i>	+	<i>Poa bulbosa</i>	++
<i>Bromus cappadocicus</i>	+	" <i>densa</i>	
" <i>glabrescens</i>		" <i>longifolia</i>	
" <i>persicus</i>		" <i>trivialis</i>	
" <i>velutinus</i>		<i>Puccinellia distans</i>	++
" <i>tomentellus</i>		<i>Secale montanum</i>	++
<i>Cenchrus ciliaris</i>	++	<i>Stipa barbata</i>	+
<i>Cymbopogon aliviesi</i>	+	" <i>lagascae</i>	
<i>Dactylis glomerata</i>	++	" <i>orientalis</i>	
<i>Festuca arundinacea</i>	++	" <i>sub-barbata</i>	
" <i>ovina</i>		<i>Triticum dicoccoides</i>	+

LEGUMES

<i>Astragalus anacardius</i>	+	<i>Melilotus alba</i>	++
" <i>chaborasicus</i>		<i>Onobrychis gaube</i>	
" <i>siliquosus</i>		" <i>lunata</i>	
<i>Coronilla varia</i>		" <i>melanotricha</i>	
<i>Hedysarum coronarium</i>	+	" <i>persica</i>	
<i>Lathyrus erectis</i>	+	" <i>pinnata</i>	
<i>Lotus corniculatus</i>	++	" <i>radiata</i>	
<i>Medicago arabica</i>	++	" <i>scorobiculata</i>	
" <i>lupulina</i>	++	<i>Trifolium dubium</i>	++
" <i>minima</i>	++	" <i>fragiferum</i>	++
" <i>orbicularis</i>	++	" <i>subterraneum</i>	++
" <i>rigidula</i>		<i>Trigonella elliptica</i>	+
" <i>sativa</i>	++	" <i>khuzestanica</i>	
" <i>truncatula</i>	++	<i>Vicia sativa</i>	++

OTHER GENERA AND SPECIES

<i>Artemisia herba-alba</i>	+	<i>Kochia prostrata</i>	+
<i>Atriplex leucoclada</i>	+	<i>Papaver bracteatum</i>	+
" <i>verruciferum</i>		<i>Poterium lasiocarpum</i>	+
<i>Camphorasma perenne</i>		<i>Salsola rigida</i>	+
<i>Haloxylon persicum</i>			

Note: + = Genus represented in South Australia } None native : all are  
 ++ = Species represented in South Australia } introduced species

APPENDIX B

ORGANIZATIONS AND PERSONS CONTACTED

(Pages 96-103)

APPENDIX BORGANIZATIONS AND PERSONS CONTACTED ON THE CONSULTANCYALGERIAMinistry of Agriculture and Agrarian Reform

Nourredine KADRA                      Director-General, IDGC, Algiers

International Centre for Maize and Wheat Improvement (CIMMYT)

George VARUGHESE                      CIMMYT Team Leader and Wheat Breeder, IDGC, Algiers

David A. SAUNDERS                      Agronomist, CIMMYT/IDGC, Oran

Walt L. NELSON                          Agronomist, CIMMYT/IDGC, Constantine

Food and Agriculture Organization of the United Nations

M.N. BAKHTRI                          FAO Regional Dryland Agronomist, Algiers

TUNISIAMinistry of Agriculture(a) Office of Livestock and Pastures

Mohamed SKOURI                      President, Director-General, Tunis

Harzallah RIDHA                      Director of Extension, Tunis

Jabeur AMMAR                          OEP Officer, Tunis

Mansour TAIEB                          Chief of Mateur Regional Office,

Amor SLIM                              Seed Production Officer, Tunis

Hassan RHAIEM                          Director, Integrated Rural Development Project, Sejenane

(b) Office of Cereals (Tunis)

Abdelhamid TOUATI                      Chief of Technical Division

Slim TOUNEKTI                          Agronomist                      "                      "

Salah REZGUI                              Agronomist                      "                      "

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M. DJERBI                              Plant Pathologist

Food and Agriculture Organization (Tunis)

Felix J. BRUCHER                          SAA/FAO Country Representative

Ford Foundation and CIMMYT (Tunis)

Werner KIENE                              Ford Foundation Representative for North Africa

John B. DOOLETTE                          CIMMYT Team Leader and Agronomist

LIBYAN ARAB REPUBLICMinistry of Agriculture and Agrarian Region (Tripoli)

H.E. Mohamed Ali TEBBO                      Minister of Agriculture and Agrarian Reform

Mahomed S. ZEHNI                          Chairman, Board of Directors, Agricultural Research Centre

Abdul Majeed BEN-SAAD                      Director-General, Agricultural Research Centre

Mansur SUGHAYER                          Director-General, Department of Forests, Range Management  
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Marwan HANNOUSH                          Forestry Specialist                      "                      "

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Hadi ARABI                                  Chief, Forestry Branch, Tripoli area

M. Naji EL-KHOGA                          Head, Animal Production Unit, Agricultural Research Centre

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E. STEFANESCO	FAO Range Ecologist
Drago DUMANCIC	FAO Range Management Specialist
T. BESKOK	FAO Forestry Expert
Ibrahim ALY	FAO Cooperative Expert

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Lloyd RADCLIFFE	Senior Farm Adviser )

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Jack BLENCOWE	Soil Conservation Adviser )
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Peter MARRETT	Agronomist ) Jebel El Akhdar
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Kamal TADROS	Head, Range Management Section

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Peter R. WEARE ODM C/- British Embassy, Amman

A. Tony WILSON	"	"	"	"	"
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SYRIAN ARAB REPUBLIC

## Ministry of Agriculture and Agrarian Reform

(a) Damascus Headquarters

Abdullah MUSRI	Director, Rangelands Division
Sayed EL-HAFEZ	Assistant Director, Rangelands Division
Mohammed DEEB	Director, Agricultural Statistics and Planning
Mustafa BOALAD	Director, Animal Breeding Division
Soliman DARWISH	Head, Cattle Breeding Section
Nizar HALLAC	Director, Animal Health Division

(b) Douma Agricultural Research Centre and Izraa Research Station

Abdelkader ARSHEED	Chief Research Director (Douma)			
Suleiman FALOOK	Director of Izraa Research Station			
Issam NAJI	Cereal Breeder and Medic Programme (Douma)			
Hanna SAWMY	Agronomist, Legume programme (Izraa Research Station)			
Fouzi BDAWI	Chief of Ministry Staff	"	"	"

(c) Hama Mohafazat

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A. TAYAR	Head, Plant Protection Section				
Riad KASSEM	Director, El Krein Centre for Sheep Improvement				
Fadel Issaf Khalid NAGY	Assistant Director	"	"	"	"
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(g) Hasakeh Mohafazat

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(h) Kamishly District of Hasakeh Monafazat

Hanna BANJARO	Director of Agriculture and Agrarian Reform
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Bahl D. SOMAROO	Plant Breeder, Forage Improvement
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Fritz BASLER	Weed Control
Donald MINEHART	Station Operations and Development

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Ayad AL-RUBAIE	

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Hasoon Aziz RAMADAN	Vice-Dean
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R.A. GUIRGIS	Wool Technology, Animal Production Department
Mohammad Ramsey TAKA	Nutrition, " " "
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Tawakol Y. RIZK	" " Weed Control
Mustafa Abdulla ALRAHEM	Farm Manager
Ramadhan A. EL-TEKRITI	Forage Quality Research
Abbas Mahdi AL-HASAN	Annual Legume Research
Azzam Sulaiman TUBAILEH	" " "
Kasim Khalil KASIM	" " "

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Mumin KARA	Head, Economics Section		
Nazmi ALINOGLU	Director, Grassland and Animal Husbandry Research Institute		
Mehmet MUNZUR	Head, Grassland Department	"	"
Ozer KURT	Technical Assistant	"	"
Gulsen SAHIN	Trigonella Research Worker	"	"
Mehmet APAYDIN	Administrative Officer	"	"

Ministry of Village Affairs (Ankara)

Mesut OZUYGUR	Director, Soil and Fertilizer Research Institute
---------------	--

Ankara University, Faculty of Agriculture

Sahabettin ELCI	Professor, Department of Forage Crops and Pastures
Omer BAKIR	" " " " "
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APPENDIX C

INTERIM REPORT TO ICARDA

(Pages 104-120)

A REPORT PREPARED

FOR

I C A R D A

A REVIEW OF THE EXISTING AND POTENTIAL ROLE OF LEGUMES IN  
FARMING SYSTEMS OF THE NEAR EAST AND NORTH AFRICAN REGION

A Brief Interim Report Only

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October, 1977

## I. BACKGROUND AND PERSPECTIVE

### 1. General

The continuing deficit in food production in the countries of the Near East and North Africa, despite the national agricultural development programmes and the considerable aid from both bilateral and multilateral agencies, has been of increasing concern for some years. While food production has increased in some countries it has declined in others (Table 1). In general, human population has increased more rapidly than have livestock numbers (Tables 2 and 3).

The Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR) decided at its meeting in April 1972 to commission a team to (i) review the research needs and priorities of the countries of the Near East and North Africa, (ii) assess the adequacy of ongoing research programmes to meet these needs, and (iii) if considered necessary, recommend measures to reinforce research on the main problems.

As a result of these deliberations by TAC a Research Review Mission spent March and April 1973 in the Near East and North Africa and recommended "the establishment of a major, internationally supported, multi-disciplinary research centre" to serve the needs of the Near East-North African Region (Skilbeck *et al.* 1973). Following this Mission and subsequent discussions the International Centre for Agricultural Research in the Dry Areas (ICARDA) was finally established in 1976 with a mandate covering five major objectives, listed by Pelton and Brough (1977) as follows:

- (i) to serve as an international centre for research into the improvement of barley, lentils and broad beans, and other such crops as may be designated by the Board of Trustees in consultation with the CGIAR;
- (ii) to serve as a regional centre, in cooperation with other appropriate international agricultural research centres for research in other crops of major importance to the region, such as wheat and chickpeas;
- (iii) to conduct research into and develop, promote and demonstrate improved systems of cropping, farming and livestock husbandry;
- (iv) To collaborate with and foster cooperation and communication among other national, regional and international institutions in the adaptation, testing and demonstration of improved crops, farming and livestock systems; and
- (v) to foster and support training in research and other activities carried out in furtherance of its objectives.

The brief interim report that follows relates especially to the third and fourth objectives of ICARDA'S mandate and particularly to the existing and potential role of pasture legumes and forage crop legumes in farming systems. However, the recognition of the value of legumes is not new: rather it is that there is a new urgency for producing more livestock feed and human food, and the need to arrest deterioration of croplands and rangelands in the Region.

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<sup>+</sup> Throughout this report the Near East will include Afghanistan, Iran, Iraq, Jordan, Syria and Turkey, while North Africa will include Algeria, Libya and Tunisia. The Region broadly embraces the countries extending from Pakistan to Morocco and from Turkey to the Sudan.

## 2. Some Historical Facts

The benefits of legumes as human food, as livestock feed, and for rehabilitation of soil fertility has been recognised for millenia in the Old World. Domestication of plants and livestock had commenced by 9000 BC and had largely run its course by 7500 BC. By c. 6000 BC, no less than fourteen different food plants including field peas, purple peas, lentils and two species of vetch were cultivated (Harlan 1976, Lehmann 1977).

Lucerne (= alfalfa i.e., *Medicago sativa* L.) a native of the Anatolian region of Turkey, the Caucasian region of southern Russia, and of the mountainous regions of Iran and Afghanistan, is thought to be the oldest cultivated forage crop (Ahlgren 1956). Just exactly when it was first cultivated is uncertain but it seems probable that it was deliberately cultivated for feeding horses during the early times of using horses and chariots (c. 1500 BC). Certainly lucerne was introduced to Greece with the invasion of the Medes and the Persians in 490 BC. Subsequently Alexander the Great took lucerne with him on his Asian expeditions of war and conquest for the purpose of growing feed for his horses and camels. Later the Romans (c. 146 BC.) acquired lucerne following their invasion of Greece.

The writings of both Columella in c. AD 50 (Ash, Forster and Heffner 1954, 1960, Vols. I, II) and Pliny in c. AD 75 (Rackham 1950, Vol. V, Book 18) specifically mention lucerne along with other legumes. Earlier Cato (234-149 BC) and Varro (116-27 BC) had detailed the benefits of using legumes for human food and animal feed (Hooper and Ash 1934). Much of the advice given on land use, also crop, pasture and animal husbandry by these four famous Roman writers is quite relevant today. And it is worth noting that several current research topics, e.g., (i) merits of various depths of ploughing or (ii) the merits of various grain legumes for soil (nitrogen) improvement when ploughed in at various green stages, alternatively harvested for grain - were also controversial issues 2000 years ago!

## II. ASSESSMENT OF THE EXISTING AND POTENTIAL ROLE OF PASTURE LEGUMES AND FORAGE CROP LEGUMES IN THE NEAR EAST AND NORTH AFRICA.

### 1. Scope and Terms of Reference of the Consultancy

There is growing recognition of the possible role and importance of pasture legumes, forage-crop legumes and food-crop legumes in farming systems in the countries of the Near East and North African Region. Although some research has been done and some information is available concerning the suitability of various legumes in the different ecological zones this evidence needs reviewing as a basis for longer-term research by ICARDA on farming systems in the Region. This forms the basis of the consultancy. During the period April-July 1977, the writer saw and discussed current research and collected information relating to the existing and potential role of legumes in fostering better cereal crop-livestock integration and production in nine countries of the Near East/North African Region. Although these studies concentrated on the availability or otherwise of suitable pasture legumes and forage-crop legumes, the important role of food-crop legumes in possible cereal crop - livestock integrated farming systems received some attention.

For logistic convenience the Region was divided into two ecological sub-regions (varying mainly in altitude) as follows:

- (i) The Milder-Winter Areas (Sub-Region A) - Visited April 11 - May 15. This included Algeria, Tunisia, Libya, Jordan, Syria and Iraq.
- (ii) The Colder-Winter Areas (Sub-Region B) - Visited June 4 - July 11. This included Turkey, Iran and Afghanistan

Of these nine countries, Algeria and Tunisia had been visited twice previously (1973, 1974) and Syria, Iraq and Iran once previously (1973). This

allowed some economy of time and choice of within-country visiting to ensure the best overall coverage of the main crop and livestock areas. However, the 20,000 km of road travel involved in this 1977 consultancy, together with previous visiting in the Region, has given a clear picture of the existing and potential land use and some of the related agronomic, economic and social problems.

The schedule of visits and main organizations contacted in the nine countries in the Region was as shown in Appendix A.

Terms of reference were as follows:

- (a) to travel to Algeria, Tunisia, Libya, Jordan, Syria, Iraq, Turkey, Iran and Afghanistan;
- (b) to review current research and existing land use involving legumes in farming systems and related tillage, fertilizer and livestock management practices;
- (c) to survey indigenous and naturalized pastures (and protected areas) to assess the occurrence of potentially-useful pasture and forage crop legumes not in current use;
- (d) to indicate the potential scope for:
  - (i) improvement of existing pasture areas by application of phosphatic (and other) fertilizer;
  - (ii) improvement of crop areas by introduction of legumes into the rotation; and
- (e) to assess the broad implications of improved crop-livestock integration (based on greater use of pasture legumes, forage crop legumes, and grain legumes) on both food crop and livestock production.

## 2. Agricultural Problems of the Near East and North African Region<sup>+</sup>

The objectives of agricultural scientists and administrators in this Region should be the same as in other areas of the world, i.e., be concerned with food and fibre production, providing an income and way of life for farmers, farm workers and associated agents and traders, and at the same time preserving the natural resources of cropping land, grazing and forest areas in perpetuity. However, in most countries of the Region there are serious deficits in the production of cereal grains, meat and milk for the rapidly-expanding population, many farmers are not making a satisfactory income and natural resources - the very bases of the crop, livestock and forest industries - are being damaged and destroyed. There is widespread irreversible damage by wind and water erosion, severe loss of cropping areas through soil salinity and complete destruction of huge areas of arid and semi-arid rangelands through uncontrolled cropping and through overgrazing. Because of these problems there is urgent need to examine priorities in agricultural research and extension and re-assess the major constraints to agricultural production. On a Regional basis, the main constraints are:

- (i) Declining soil resources - through desert encroachment in the steppe, water erosion in areas of higher precipitation and soil salinity in both irrigated and rainfed areas.

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<sup>+</sup> This section is based on a paper presented by the author in Pakistan 1975 in association with the FAO/UNDP Regional Meeting, Carter (1975b).

- (ii) Poor soil structure - associated with low levels of soil organic matter and faulty tillage practice (e.g. when soil is too wet or too dry). Deep ploughing aggravates the soil structure problem in some countries (e.g. Algeria) while the heavy deposition of clay in irrigation waters must aggravate infiltration problems. (Leguminous food crops, forage crops or grazed pastures in the rotation could greatly improve soil structure, permeability and soil nitrogen levels).
- (iii) Unsuitable tillage and sowing equipment - this increases costs and decreases yields. The more dry the district the more important is timing of operations. There must be a compromise between problems of displaced labour and the necessity for correct timing of tillage and sowing operations. Machinery syndicates, contractors and Government-owned equipment can all play an important part in improving efficiency of farm operations. Voluntary amalgamation of small holdings could also greatly help in mechanization of such operations as land-levelling on irrigated areas.
- (iv) Serious weed problems - decreasing crop yields and increasing costs of production.
- (v) Poor volunteer pastures - low in density and productivity, low in legumes and nutritive value. More phosphatic fertilizer is needed to encourage self-regenerating legumes (e.g. annual species of *Medicago* and *Trifolium*). Top-dressing of hill country with superphosphate (adding appropriate seeds where needed) could greatly increase the livestock feed supply on many areas in the Region (e.g. Anatolian Plateau of Turkey, northern Iraq, Iran and Afghanistan and the coastal hills of Algeria and Tunisia) and concurrently reduce the catastrophic soil erosion, reduce flooding damage, and the siltation of reservoirs and irrigation systems.
- (vi) Inadequate crop-livestock integration - contributing to overgrazing and erosion problems and to under-grazing and weed problems. There is great scope throughout the Region for organized movement of livestock from the arid rangelands and steppe to the cereal-livestock and irrigated (also higher-rainfall) zones of the various countries.
- (vii) Insufficient trained production research workers, extension workers, field technicians and farmers - There is an unacceptable discrepancy between research findings and farm practices. This discrepancy between crop yields at research farms and those commonly obtained by the farmer highlights several problems. While it is the duty of research workers to establish the biological maximum yields e.g., establish the ecological possibilities of a particular cultivar with maximum inputs it is also the responsibility of agricultural scientists to establish the economic practicability of various combinations of inputs i.e., to establish a range of options. We know that, for various reasons, many farmers will not or cannot use adequate fertilizer and other optimal cultural practices, therefore in formulating recommendations these facts have to be considered. More experiments are needed on farmers' fields using farmers' methods. These need to be side-by-side with

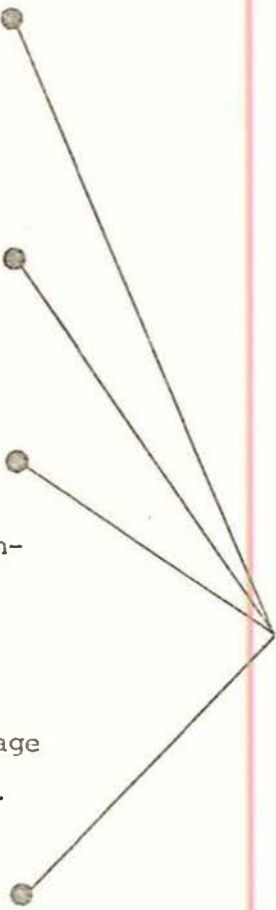
experiments using a range of inputs.

On-job training courses are needed at all levels down to the farmers and field workers but the basic problem lies in the need for upgraded education at all levels.

- (viii) Insufficient credit arrangements and production incentives - Many farmers of the Region need more encouragement and security. There are needs for policies to upgrade the interests and motivation of the farmers through provision of adequate credit and incentives (even subsidies) guaranteed markets and fair prices.

Having regard to the shortage of trained research workers in most countries of the Region it is quite clear that, in the Region as a whole, there is adequate (and even a disproportionate) emphasis on Plant Breeding yet there is quite inadequate attention to cultural practices for the various crops. Tillage practices; time, rate and depth of sowing; fertilizer forms and rates; weed control; pest and disease control require much more attention and may well provide the main impact on production in the next decade. Many more broadly-trained Crop and Pasture Agronomists are needed in the Region to ensure real progress at the farm level. Better-trained, better-paid and more-mobile Extension Workers are needed for working with the farmers on the farms. The components of integrated agricultural systems are as follows:

1. Soil and Water Management  
Soils, fertilizers, irrigation water, drainage, salinity, etc.
2. Field Crops Sector  
Plant improvement and agronomic practices.
3. Pasture-livestock Sector  
Steppe and arid rangeland.  
Cereal zone and higher rainfall zone.  
Topdressing with phosphate to improve annual self-regenerating legumes. Forage legumes in irrigated areas.
4. Socio-Economic Infrastructure  
Agricultural credit, price incentives, storage and marketing. Mechanization versus labour and the role of machinery syndicates, contractors, etc.



These are the four main determinants of systems of agriculture. Integration of these factors will generate new systems which will need to be modified according to climate, soil, locality and socio-economic state at the farm, the village, the province and the country level.

### 3. Existing and Potential Role of Pasture and Forage-Crop Legumes<sup>+</sup>

The role of the self-regenerating, annual pasture legumes notably subterranean clover (*Trifolium subterraneum* L.) and barrel medic (*Medicago truncatula* Gaertn.) in southern Australian agriculture has been well-documented (e.g. Carter 1965, 1975b; Donald 1965, 1970). The possibility of transferring the southern Australian technology of establishment and management of these legumes to North Africa and the Near East has been examined sporadically over the past twenty years or so (Gallacher 1972, Carter 1974b).

In recent years the increased cost of nitrogenous fertilizers has caused a resurgence of interest in the potential role of pasture legumes and forage crop legumes, especially in North Africa (Carter 1974a, b; 1975a, b; Doolette 1976; Leeuwrik 1976; Saunders 1976). In this respect it is worth noting that Australian cultivars of annual *Medicago* spp. perform well in Algeria, Tunisia and Libya with one notable exception - the high plateau of Algeria where the local ecotypes, because of cold-hardiness, are superior - (Adem 1974; Carter 1974b; 1975a; Saunders 1976).

Some Libyan farm development projects based on sowing Australian cultivars of medic deserve special mention. The Jeffara Plain Development Project on sandy soils in the Tripoli region, the Benghazi Plain Development Project, and the Jebel El Akhdar Development Project based mainly on heavy textured soils of the El Marj region have had good success with Australian medics when rainfall has been adequate in the year of establishment. However, this does not exclude the possibility of superior performance of some of the local ecotypes of several species of annual medic and this possibility is being examined in conjunction with the South Australian Department of Agriculture and Fisheries.

Parts of North Africa are suited to subterranean clover where neutral to acidic soils occur and where mean annual rainfall exceeds 450 to 500 mm (Carter 1974b, 1975a). One such area is at Sejenane in northern Tunisia where the Integrated Rural Development Project, co-sponsored by the Tunisian Ministry of Agriculture and the West German Government, involves *inter alia* the clearing of light timber and bush and establishing sown pastures based on Australian cultivars of subterranean clover. There is a substantial potential for pasture improvement and greatly increased livestock production from this region.

In the Near East, greater pressures on land use and more climatic constraints have limited the progress in pasture improvement. Certainly there are areas in Jordan, Syria, Iraq, Turkey, Iran and Afghanistan that can usefully use Australian cultivars of annual medics and subterranean clover but there is a much smaller percentage of suitable environments for these annual species than in North Africa. A major constraint in the Near East has been the disproportionate emphasis on imported herbage plants from North America, Europe and Australia and an almost total neglect of locally-occurring ecotypes of pasture legumes, forage crop legumes, grasses, etc. However, there are some very active research groups in the Near East who are concerned with legumes for crop rotations, and the general need for improvement of sown pastures, forage crops and rangelands.

The main rainfed cereal growing areas of Jordan, Syria and Iraq can be grouped with the North African countries of Algeria, Tunisia and Libya under the general heading of the milder-winter areas. In these situations

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<sup>+</sup> Definitions of pasture, forage crop, rangeland, etc., are given in Appendix B

the scope for medics and, to a small extent, subterranean clover in these Near East situations is similar to that in North Africa. Similarly there are small areas in Turkey, Iran and Afghanistan capable of growing commercially available, i.e. Australian cultivars, of annual medics and subterranean clover. However, there are sound reasons to expect better performance from local-ecotypes of pasture and forage crop legumes. In the transitional, colder areas of Jordan, Syria and Iraq, just as on the high plateau of Algeria, it is essential to develop local ecotypes of medics, clovers, vetches, etc.

In Jordan and Syria there is currently little use made of annual medics and clovers in cereal rotations, though vetch is common. However, the continuous break-down of hardseeds of vetch under the following wheat crop commonly causes some problems of plant competition. There is growing concern and interest in range management and pasture and forage crop development in Syria and elsewhere (Draz 1969, 1974).

In Iraq the Mosul University group are enthusiastic at the prospect of using annual medics and vetches in rotation with cereals and have done some good work (e.g., Al-Fakhry 1974; Radwan *et al.*, 1974; Radwan and Al Fakhry 1975; Radwan, Al-Fakhry and Al-Hasan 1975; Al-Hasan 1976; Mohammad 1976).

The colder-winter environments of Turkey, Iran and Afghanistan have special problems regarding the unavailability of commercial lines of annual pasture seeds though lucerne seed (local and imported) is commonly available. In Turkey substantial progress has been made in the selection of both pasture and forage crop legumes, and other species. The Ministry of Agriculture Grassland and Animal Husbandry Research Institute at Ankara and the Department of Forage Crops and Pastures in the Faculty of Agriculture, University of Ankara, have done useful selection on several species including *Vicia* spp., *Medicago sativa*, *Trifolium fragiferum*, *T. pratense* (Elci 1975) *Onobrychis sativa*, *Trigonella* spp. (Alinoglu, Priv. Com.) as well as on the role of legumes in lieu of fallow in the traditional wheat fallow rotation (Bilensoy 1970, Bakir 1976, Alinoglu 1977). However, these research groups at Ankara are severely constrained through inadequate funds, especially for items of equipment and transport for field visiting.

The most impressive range of pasture and forage crop research activities seen in the whole Region during this consultancy was at The Ataturk University and Ministry of Agriculture at Erzurum in eastern Anatolia. Of course, this is mainly a pasture-livestock environment. Pasture and forage crop legume selection work included *Medicago sativa*, *Onobrychis sativa*, *Trifolium ambiguum* and *Trifolium pratense*. In this relatively isolated location it was clear that there was excellent cooperation within and between the University Departments of Crop Science, Soils and Animal Science and also between the University Faculty of Agriculture and regional representatives of the Ministry of Agriculture. In the Erzurum region (c.1800 m. altitude and above) some excellent meadows with yielding capacity up to c. 12000<sup>†</sup>kg DM/ha were seen, but on the well-drained and rocky slopes the native rangelands are quite unproductive though these are capable of improvement (Tosun *et al.*, 1977).

Pasture and forage crop research in Iran is handled mainly by the Research Institute for Forests and Rangelands which is taking active steps to collect locally occurring ecotypes of native species with a view to evaluating these alongside imported species mainly from North America and Europe. However, this work is in its infancy. Although the rangelands

<sup>†</sup> In a very favoured micro-environment : more commonly 4000-8000 kg DM/ha.

of Iran, in common with the rest of the Region, are in very poor condition over huge areas, active measures have been instituted to preclude grazing or control grazing. This has led to a dramatic improvement in range condition. In particular, the restriction of grazing on reservoir catchment areas is most beneficial in limiting the reservoir intake of soil and other contaminants. Of particular interest on the high mountain sites (c. 3000 m altitude) is the occurrence of *Trifolium radicosum*, a prostrate perennial, with obvious scope for development for the purpose of aerial sowing on some of the high mountain watershed areas of Iran.

In Afghanistan, shortage of trained personnel, equipment, general working expenses, and transport has greatly restricted efforts to preserve the rangelands let alone effect improvements. However, there is considerable scope for use of pasture and forage crop legumes. The Herat Livestock Development Corporation with support from the World Bank is promoting the use of lucerne, Persian clover (*Trifolium resupinatum*) and Berseem clover (*T. alexandrinum*) for hay production where some water is available for supplementing normal precipitation.

### III. CONCLUSIONS AND RECOMMENDATIONS

1. There is no shortage of local ecotypes of a great range of potentially-useful pasture and forage crop legume species throughout the Near East and North African Region. However, the virtual absence of a seed industry for herbage plants has greatly restricted exploitation of many ecotypes which include annual and perennial *Medicago* spp. and *Trifolium* spp., *Onobrychis* spp. *Vicia* spp. and *Trigonella* spp. There is an urgent need for plant collection, correct identification, evaluation and, if promising, seed increase.
2. There is considerable merit in ICARDA involving such groups as the Plant Introduction Section of the South Australian Department of Agriculture and Fisheries in a cooperative effort to assist in collection and evaluation of pasture and forage crop legumes. Later, such groups as the South Australian Seedgrowers Cooperative could greatly assist in seed multiplication of selected species or cultivars. Of course the main testing would have to be done at relevant sites in the Near East or North Africa.
3. There is a definite need and a role for commercially-available pasture and forage crop legume seeds from such places as Australia, Europe and North America (depending on species) until such time as seed from superior local ecotypes is available.
4. Research on pastures and forage crops in traditional cereal growing areas should concentrate almost wholly on legumes as livestock feed and for soil improvement. Any research on pasture grasses should be confined to the potential for non-arable sites or semi-arid rangelands.
5. The above suggestions refer to the bio-ecological aspects of the adaptation of species to a particular environment. Certainly the huge range of genetic variability needs to be evaluated before any breeding work is contemplated.
6. Any new legume species (or cultivars) proposed for grazed pasture or forage crop must be evaluated in part under grazing to assess response to defoliation and treading and also to check for toxic principles (though the latter can best be done under pen-feeding conditions).

7. The soil/plant/animal/socio-economic complex will dictate existing and potential new farming systems. Sheep are the most important livestock in the Region : hence sheep should form the basis of the ICARDA-supported livestock research in the Region. As the main constraint to livestock production is feed supply, if systems can be evolved to provide adequate feed for sheep then there should be sufficient feed for alternative livestock. There is no case for undertaking detailed research on camels, cattle or goats in the Region. Many dairy herds in the Region are relatively isolated from the environment.

8. The best prospect for increasing feed supply for livestock in the Region lies in the production of leguminous pasture and forage crops in rotation with cereal crops and for improvement of pasture production in some of the hill and mountain country. Oversowing of legume seed and use of phosphatic fertilizer could greatly improve productivity of native and sown leguminous pasture in many areas of the Region. Increased feed supplies in the traditional cereal-growing areas, and higher-rainfall areas, will reduce grazing pressure on the rangelands.

9. Fodder conservation and supplementary feeding will continue as an integral part of livestock production in the Region. Research on the most efficient use of locally-grown feeds and the blending of appropriate feedmixes, will require that both the Aleppo and Tabriz Centres of ICARDA should have sheep breeding flocks of adequate size to ensure the availability of even lines of experimental animals, also good sheep-handling facilities (yards, drafting race, clockface sheep - weighing scales and cage, sheep dip, shearing shed, etc.).

10. In addition to normal sheep-handling facilities, it will be essential to have a separate animal house with *in vivo* digestibility pens for harnessed sheep (faecal collection) plus cold storage and dehydration facilities. Furthermore, *in vitro* laboratory digestibility equipment will be required.

11. The main conclusion reached from this further 20,000 km of road travel in North Africa and the Near East is that the outstanding rural problem of the Region is the disastrous deterioration of natural resources, viz:

- . decline in the area of useful arable land through erosion caused by reckless cultivation, and through soil salinity;
- . decline in the area of rangeland through uncontrolled cultivation, consequent denudation and desert encroachment; and
- . decline in rangeland productivity through overgrazing and removal of shrubs and trees for fuel.

Of course these three components of the degradation of natural resources are closely inter-related and result from the rapid rise in both human population and livestock numbers, especially in the past 30 years.

12. The gross neglect of the pasture-rangeland-livestock sector (based mainly on common lands) relative to the administrative and research attention to the cropping areas in the Region is a matter for great concern. Research on pasture and forage crop legumes will have limited impact without concurrent actions designed to preserve and/or improve the common grazing lands. The rehabilitation of common grazing lands will require a delicate blend of political, social, economic and technical expertise, and site-specific research data will be needed to assist in decision-making. Any consideration of farming systems by ICARDA must necessarily involve the above problems. Hence it will be most important for ICARDA to work closely with existing national research programmes. In most countries of the Region there are research groups who are concerned with improvement of the pasture-rangeland-livestock sector. These groups include enthusiastic, young well-trained staff, but they need encouragement, guidance, and in some cases financial assistance.

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TABLE 1

INDICES OF POPULATION, AGRICULTURAL PRODUCTION, AND AGRICULTURAL PRODUCTION  
PER CAPUT IN 1975 IN NINE COUNTRIES OF THE NEAR EAST-NORTH AFRICAN REGION.

(1961-65 = 100)

	<u>Population</u>	<u>Agriculture</u>	<u>Agric.Prod/Caput</u>
Afghanistan	133	126	95
Algeria	148	96	65
Iran	141	162	115
Iraq	147	140	95
Jordan	147	58	39
Libyan A.R.	150	210	140
Syrian A.R.	145	131	90
Tunisia	129	188	146
Turkey	134	155	115

Source: FAO Production Yearbook Vol.29, 1975.

TABLE 2

COMPARATIVE CHANGES IN POPULATION AND LIVESTOCK NUMBERS OVER A TWELVE-YEAR PERIOD 1963 TO 1975 IN NINE COUNTRIES OF THE NEAR EAST-NORTH AFRICAN REGION

	People ('000)	Cattle <sup>+</sup> ('000)	Sheep <sup>+</sup> ('000)	Goats <sup>+</sup> ('000)	Camels <sup>+</sup> ('000)
Afghanistan					
1963	14474	3230	17940	3757	318
1975	19280	3610	17300	2350	300
Change	+33.2%	+11.8%	-3.6%	-37.5%	-5.7%
Algeria					
1963	11383	810	6180	1950	165
1975	16792	1245	8600	2300	180
Change	+47.5%	+53.7%	+39.2%	+17.9%	+9.1%
Iran					
1963	23261	5060	30410	13006	234
1975	32923	6500	35000	14000	60
Change	+41.5%	+28.5%	+15.1%	+7.6%	-74.4%
Iraq					
1963	7657	1531	10138	2209	200
1975	11067	2116	15829	2675	338
Change	+44.5%	+38.2%	+56.1%	+21.1%	+69.0%
Jordan					
1963	1858	61	752	592	17
1975	2681	49	792	400	16
Change	+44.3%	-19.7%	+5.3%	-32.4%	-5.9%
Libyan A.R.					
1963	1549	106	1378	1281	266
1975	2255	121	3329	1109	120
Change	+45.6%	+14.2%	+141.6%	-13.4%	-54.9%
Syrian A.R.					
1963	4958	454	4035	668	11
1975	7259	504	5310	684	8
Change	+46.4%	+11.0%	+31.6%	+2.4%	-27.3%
Tunisia					
1963	4113	562	3125	613	158
1975	5747	870	3400	661	211
Change	+39.7%	+54.8%	+8.8%	+7.8%	+33.5%
Turkey					
1963	29628	12621	32863	22665	54
1975	39882	13387	40539	18746	19
Change	+34.6%	+6.1%	+23.4%	-17.3%	-64.8%

<sup>+</sup>The livestock numbers shown for 1963 are mean figures for the period 1961-65.

Source: FAO Production Yearbooks Vol.26, 1972 and Vol.29, 1975.

TABLE 3

COMPARATIVE CHANGES IN POPULATION AND LIVESTOCK NUMBERS OVER  
THE TWELVE-YEAR PERIOD 1963-75 IN THE TWO SUB-REGIONS  
OF THE NEAR EAST-NORTH AFRICAN REGION

	People ('000)	Cattle <sup>+</sup> ('000)	Sheep <sup>+</sup> ('000)	Goats <sup>+</sup> ('000)	Camels <sup>+</sup> ('000)
<u>Sub-Region A</u>					
1963	31518	3524	25608	7313	817
1975	45801	4905	37260	7829	873
Change	+45.3%	+39.2	+45.5	7.1%	+6.9%
<u>Sub-Region B</u>					
1963	67363	20911	81213	39428	606
1975	92085	23497	92839	35096	379
Change	+36.7%	+12.4%	+14.3%	-11.0%	-37.5%
<u>Total of all Nine Countries</u>					
1963	98881	24435	106821	46741	1423
1975	137885	28402	130099	42925	1252
Change	+39.4%	+16.2%	+21.8%	-8.2%	-12.0%

<sup>+</sup>The livestock numbers shown for 1963 are mean figures for the period 1961-65.  
 Sub-Region A = Algeria, Tunisia, Libyan A.R., Jordan, Syrian A.R. and Iraq.  
 Sub-Region B = Turkey, Iran and Afghanistan.

Source: FAO Production Yearbooks Vol.26, 1972 and Vol.29, 1975.

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APPENDIX A

1. Schedule of Air Travel Between and Within Countries in 1977

				<u>Flight</u>	<u>Departing</u>
Mon.	April	11	London - Algiers	BR335	1015hr
Tues.	"	12	Algiers - Tunis	LN312	1125
Sat.	"	16	Tunis - Tripoli	SV778	1445
Mon.	"	18	Tripoli - Benghazi	LN418	1925
Wed.	"	20	Benghazi - Cairo	MS838	1000
"	"	20	Cairo - Amman	RJ502	1430
Fri.	"	29	Amman - Damascus	By road	0700
Tues.	May	10	Damascus - Baghdad	RB361	0700
(Sun.	"	15	Baghdad - Frankfurt	LH611	0800 )
(			To attend Int. Grassland Congr., Leipzig, G.D.R.)		
Sat.	June	4	E.Berlin - Istanbul	TK972	1200
"	"	4	Istanbul - Ankara	TK146	1730
"	"	11	Ankara - Erzurum	TK284	1215
Tues.	"	14	Erzurum - Ankara	TK285	1415
Wed.	"	15	Ankara - Teheran	IR752	1945
Mon.	July	4	Teheran - Kabul	IR820	0430
"	"	11	Kabul - Delhi	FG322	0930

2. Main Organizations Contacted during the Consultancy

Algeria: (i) Ministry of Agriculture and Agrarian Reform (MARA);  
(ii) FAO; (iii) The Ford Foundation/CIMMYT.

Tunisia: (i) Ministry of Agriculture; (ii) FAO/UNDP;  
(iii) The Ford Foundation/CIMMYT.

Libya: (i) Ministry of Agriculture and Agrarian Reform; (ii) FAO/UNDP;  
(iii) Jeffara Plains Development Authority; (iv) Jebel El Akhdar  
Development Authority. (Also attended part of Seminar on Wheat  
Research in Tripoli).

Jordan: (i) Ministry of Agriculture and Supply; (ii) FAO; (iii) The Ford  
Foundation; (iv) University of Amman. (Also attended part of  
Barley Workshop in Amman).

Syria: (i) Ministry of Agriculture and Agrarian Reform; (ii) FAO;  
(iii) ICARDA; (iv) University of Aleppo; (v) ACSAD.

Iraq: (i) Ministry of Agriculture and Agrarian Reform; (ii) FAO;  
(iii) University of Mosul.

Turkey: (i) Ministry of Agriculture; (ii) Ministry of Village Affairs;  
(iii) FAO; (iv) The Rockefeller Foundation; (v) University of  
Ankara; (vi) Ataturk University, Erzurum.

Iran: (i) Ministry of Agriculture and Natural Resources; (ii) FAO;  
(iii) ICARDA; (iv) University of Tehran.

Afghanistan: (i) Ministry of Agriculture; (ii) FAO/UNDP; (iii) Herat Live-  
stock Development Corporation; (iv) Helmand Valley Authority;  
(v) University of Kabul.

## APPENDIX B

### DEFINITIONS OF PASTURE, FORAGE CROP AND FODDER

While there is no universal agreement on terminology, the following definitions apply to the terms, listed below, that are used throughout the report.

- (1) Pasture: A dynamic community of plants subjected to the various influences of the grazing animal (treading, defoliation, recycling of nutrients, dispersal of seeds). The pasture may be a mono-specific sward or a complex community of many genera and species.
- (2) Native Pasture: Pasture dominated by indigenous perennial species (but often with associated annual species), including both climax and disclimax pastures.
- (3) Natural Pasture: Volunteer (or spontaneous) pasture resulting from the activities of man and his grazing animals but without artificial sowing. Natural pasture is commonly characterised by dominance of annual species, frequently naturalized species introduced from elsewhere. The volunteer species may be the same species as are frequently sown, e.g., the spread of *Medicago truncatula* and *Trifolium subterraneum* in southern Australia.
- (4) Sown Pasture: Annual and/or perennial species sown (usually with fertilizer) to increase the livestock carrying capacity of the area. The process is also referred to as pasture improvement when one or more species is introduced either on cultivated soil or into native or natural pasture.
- (5) Permanent Pasture: Pasture developed by sowing perennial species with or without associate annuals and usually in higher-rainfall areas. The perennial species confer stability of botanical composition.
- (6) Rangeland: Arid-zone pasture (including steppe) dominated by perennial species and generally not capable of improvement without exclusion of grazing animals, and furrowing etc., to collect seed and water. Conservative stocking is obligatory.
- (7) Forage Crop: Green crop sown to supplement normal pasture and frequently cut and carted to feed livestock. These forage crops may be sown annual species e.g., barley-vetch for winter feed; turnips, sudan grass, etc., for summer feed; or perennial species like lucerne.
- (8) Fodder: Any dried and stored or conserved feedstuff e.g., cereal hay, straw, cereal grain, pasture hay, forage hay, swedes, fodder beet, etc.